The Rifle in War

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Army School of the Line

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THE RIFLE IN WAR

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Fort Leavenworth, Kansas
1908

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The Battle Efficiency of the Small Arm

FOREWORD

The subject is considered under two heads:

1. The Effect of Small Arm Fire, and
2. The Means of Securing Superiority of Fire.

The modern infantry rifle is an instrument of precision and is a very powerful weapon. To attain the maximum of effect, it is necessary that he who assumes to direct or control its use should study its powers and limitations—not the powers and limitations of the single rifle, but of hundreds of rifles acting simultaneously, and not only of many rifles fired on the testing grounds, but of many rifles fired by and considered in conjunction with the human, error-introducing soldier who will use it in war.

He, on the one hand, who is engaged in the manufacture of fire arms or who seeks to perfect himself in marksmanship must study the rifle itself and from a certain class of experiments and data arrive at conclusions upon which to base his actions. He, on the other hand, who as a leader of troops in battle will reap the reward of success or shoulder the blame for failure of a tactical decision where "*Fire is everything, the rest of small account*", must study the rifle and the soldier in an inseparable union, and from the study of this combined weapon and of data quite different from that above considered, he must arrive at conclusions which will govern his actions in the moment of supreme trial.

In the following pages, much will be found that appears didactic and much that appears pure theory

with no practical end in view; but to attain a thorough knowledge of this, as of any other subject, it is believed necessary that the student should start at the bottom, lay a firm and broad foundation of elementary knowledge, and, upon this, rear the completed strucure which shall have a war value. In doing this it is inevitable that some theory should be included and that some didactic statements should be made.

The use of mathematics is as limited as is consistent with an understanding of the subject and only elementary mathematics are used. Further, the author, mindful of the fact that the subject is a study of rifle firing rather than of mathematics, has made many long leaps from the statement of the problem to the calculated result, seeking to impart a lesson and to point a moral rather than to carry the student through the sometimes long computations by which the result was obtained. The student is, therefore, able to read and grasp the lesson sought to be imparted without losing the thread of the argument by a digression into other fields.

There are certain elementary principles with which the student is presumed to be familiar and explanations and definitions are given, such as are not commonly found in text books on elementary musketry. The method employed of comparing the size of shot groups and the relative dispersion is that which has for years been the basis of inquiries into the effect of fire by artillerists and is now used by all scientific infantrymen for reasons that will be made apparent.

CHAPTER III

All inquiry into the effect of fire is based upon a thorough understanding of the cone of dispersion of fire, for whatever conclusions may be reached as to the influence of this or that modifying factor, the ultimate conclusion will involve a consideration of the dimensions of the dispersion.

A number of projectiles fired from the same rifle will not, each follow the same path, but each trajectory will differ from the others more or less according to the perfection of the rifle and ammunition, the skill of the firer and the atmospheric conditions. Considered together, these several trajectories form a kind of curved cone or sheaf with its apex at the muzzle of the gun and its dimentions increasing with the distance. A cone or sheaf of fire received on a vertical surface covers that surface with a group of hits larger or smaller according to the size of the sheaf and having the general form of a circle up to about 700 or 800 yards and of an ellipse at longer ranges with its major axis horizontal.

The figure, thus formed is called a vertical shot group. If the sheaf is received on a horizontal surface, the figure formed by the falling projectiles is called a horizontal shot group, which differs from the vertical shot group in that at the shorter ranges it forms an ellipse with its major axis lying in the direction of the fire and that it approaches a circular form at the extreme ranges.

There is an intimate relation between the vertical dimension of the vertical shot group and the longitudinal dimension of the horizontal group so that if the last element of the trajectory be considered a

straight line, the vertical dimension of the vertical group will be equal to the tangent of the angle of fall times the longitudinal dimension of the horizontal group. For example, the angle of fall at 1100 yards is 2° (tan. $=0.034920$) and if the depth of the vertical shot group is 65.5 yards at 1100 yards, then the vertical dimension of the vertical shot group is $0.034920\times 65.5\times 36=82.3$ inches. Conversely, if the vertical dispersion is 82.3, the dispersion in depth will be $\frac{82.3}{36\times .03492}=65.5$ yards.

The dimensions of the shot groups form the basis for all study in effect, as has been stated, for if we consider an infinitely small group, so that every shot fired fall in the same place, then, if properly aimed, every shot will hit the target, whereas with a large shot group (dispersion) and the same correctness of aim, only a portion of the group will hit the target, those shots on the edges of the group being scored as misses which fall outside the target, and it is only when the target has been enlarged to the same or greater dimension as the group will all shots fired hit the target. It is thus evident that—

(1.) The smaller the size of the dispersion, or
(2.) The greater the size of the target, the

greater will be the chance that all the shots fired will hit the target. That an intimate inter-relation exists between these two factors is also apparent.

The hits in any group are seemingly distributed without any law, but it is known that they will be most dense around a point situated at about the center of the group, called the "center of impact" or, sometimes referred to as the "mean" or "middle" point of impact. Further, it is known that the density of the shot group decreases in all directions from the center of impact, gradually at first and then more

rapidly until toward the edges of the group there are but few hits.

The "Accuracy Tables" as issued by our Ordnance Department are based on the mean deviation (vertical and horizontal) considering all the shots in the group, but contain no information as to the size of the group or its density, these can only be found by the theory of probabilities and then only for a vise-held rifle.

For the gun maker or the marksman this information is very important, but for the student of the probable effect of rifle fire, as has been said, another class of information is necessary. Two other methods are used in Europe, in the first a circle is so drawn as to include 50 per cent of all the hits, and the radius of this circle is taken as the measure of the accuracy; in the other, which is now the generally adopted method, strips are drawn across the target of such a width as to include 50 per cent of all hits, and this method makes it possible to determine the probable effect of fire against all sizes and shapes of targets.

On a vertical shot group a horizontal strip is drawn, symmetrical to the center of impact of such dimensions as to include one-half, or 50 per cent of all the hits made on the group. This space is called the "MEAN VERTICAL DISPERSION" (50 per cent). A similar strip drawn vertically gives the "MEAN LATERAL DISPERSION" (50 per cent). On a horizontal target, similar strips are drawn, the vertical dispersion of the vertical group becoming the "MEAN LONGITUDINAL DISPERSION" or the "dispersion in depth" of the horizontal group, and being equal to the M.V. dispersion ~~in depth multiplied~~ by the tangent of the angle of fall.

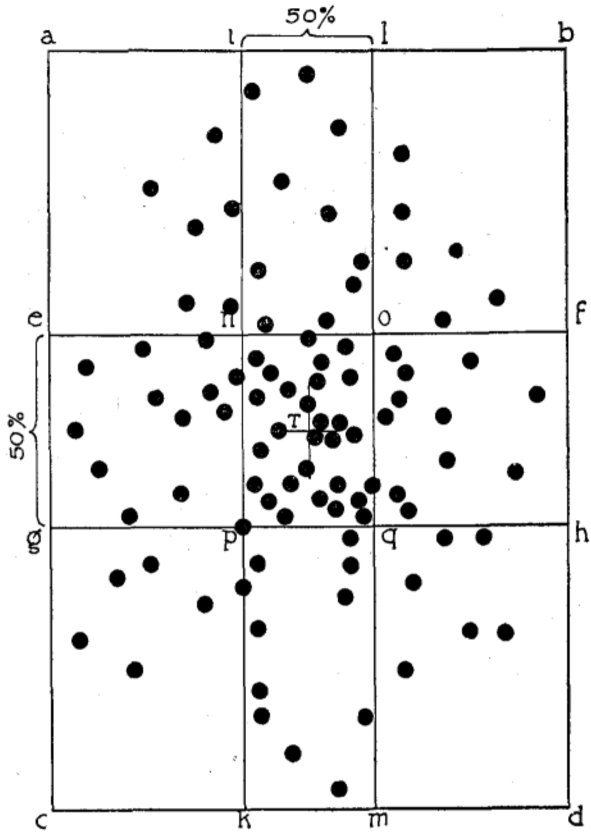


Fig 1.

Figure 1 shows a shot group with its center of impact at T and of such dimensions that every shot falls somewhere within the rectangle a b c d. The lines e f and g h are so drawn, parallel to each other and symmetrical to the center of impact, as to include half of all the shots in the group, their distance apart thus being the measure of the mean vertical dispersion.

Similarly the lines i k and l m, include half of all

the shots and the distance n o, or p g is the mean lateral dispersion. Within the rectangle n o p g will be found .50×.50=.25 per cent of all the shots.*

If we consider the group as having been made by the firing of a very great number of shots, then by the theory of probabilities we may determine a law by which the density at any point of the group may be ascertained.

Omitting a discussion of the "Theory of Probabilities", it is shown by that theory that a strip, horizontal and symmetrical, with the center of impact and one-half the width of the mean vertical dispersion will contain, not 25 per cent of hits, but 26.4 per cent of hits. Similarly, a strip twice as wide as the mean dispersion will contain, not 100 per cent of hits, but 82.4 per cent; 1½ times as wide as the mean dispersion will contain 68.5 per cent, instead of 75 per cent, etc.

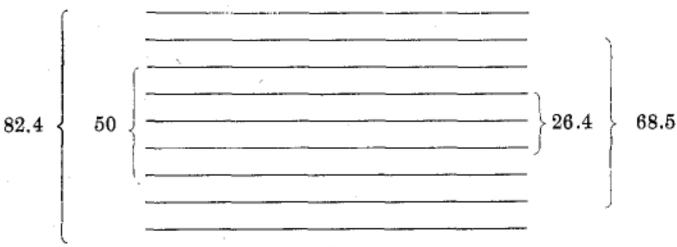


Fig. 2

In this way, the density of any of the strips may be calculated; thus, if the density of hits in the inner strip (26.4 per cent) be considered as unity, then in the next included (50 per cent) will be included 50—26.4 or 23.6 per cent of the hits and the relative density of this strip will be 0.89; similarly, in the other strips, the relative density will be found to be

* In France and in many other countries, the 50 per cent dispersion is not used as a measure for the accuracy, but the probable deviation (écart probable), that is to say one half the mean dispersion.

We thus find Lamiraux and other French ballisticians referring to the mean vertical dispersion as the "Probable double vertical deviation" etc.

0.69, and 0.53, respectively. If we continue the subdivision of the group in this manner, we will be able to deduce a table of probable density factors for all percentages from 1 per cent to 100 per cent, as has been done ~~in table 1.~~

TABLE ONE

PROBABILITY FACTORS

Per C't	Factor	Per C't	Factor	Per C't	Factor	Per C't	Factor
1	0.02	26	0.49	50	1.00	75	1.71
2	0.04	27	0.51	51	1.02	76	1.74
3	0.06	28	0.53	52	1.04	77	1.78
4	0.07	29	0.55	53	1.07	78	1.82
5	0.09	30	0.57	54	1.09	79	1.86
6	0.11	31	0.59	55	1.12	80	1.90
7	0.13	32	0.61	56	1.14	81	1.94
8	0.15	33	0.63	57	1.17	82	1.98
9	0.17	34	0.65	58	1.19	83	2.03
10	0.18	35	0.67	59	1.22	84	2.08
11	0.20	36	0.70	60	1.25	85	2.13
12	0.22	37	0.72	61	1.27	86	2.18
13	0.24	38	0.74	62	1.30	87	2.24
14	0.26	39	0.76	63	1.33	88	2.30
15	0.28	40	0.78	64	1.36	89	2.37
16	0.30	41	0.80	65	1.39	90	2.44
17	0.32	42	0.82	66	1.42	91	2.52
18	0.34	43	0.84	67	1.45	92	2.60
19	0.36	44	0.86	68	1.48	93	2.69
20	0.38	45	0.89	69	1.51	94	2.78
21	0.40	46	0.91	70	1.54	95	2.91
22	0.41	47	0.93	71	1.57	96	3.04
23	0.43	48	0.95	72	1.60	97	3.22
24	0.45	49	0.98	73	1.64	98	3.45
25	0.47	50	1.00	74	1.67	99	3.82

TABLE III.

Firing Table for 1903 Rifle, and 1906 Bullet

DISTANCE	ANGLE DEPARTURE		ANGLE OF FALL		REMAINING VELOCITY	DANGEROUS ZONE †		(50 Per Cent) MEAN DISPERSION **			SUMMITS		NATURAL TANGENTS	
						Inf.	Cav.	Vertical	Lateral	Longitudinal	Height	Distance from Muzzle	Angle of Departure	Angle of Fall
Yards	Deg.	Min.	Deg.	Min.	Ft. per sec.	Yards	Yards	Inches	Inches	Yards	Feet	Yards		
100	0	2.424	0	2.576	2465.09	680.9	271.6				.055	50.9	.00070	.00075
200	0	5.153	0	5.828	2244.75	547.3	666.5				.241	103.8	.00150	.00169
300	0	8.275	0	12.196	2038.58	540.4	676.8				.595	157.5	.00241	.00355
400	0	11.833	0	14.594	1846.02	572.9	633.7	31.9	31.9	208.0	1.168	212.4	.00344	.00424
500	0	15.918	0	21.937	1668.16	628.3	670.5	38.9	38.9	169.0	2.035	270.5	.00463	.00638
600	0	20.651	0	30.436	1507.32	696.7	731.9	44.6	44.6	138.5	3.273	329.5	.00601	.00886
700	0	26.105	0	41.104	1362.04	185.8	801.5	48.0	48.8	111.5	4.989	390.1	.00759	.01196
800	0	32.441	0	54.543	1237.75	129.6	200.2	55.2	56.8	96.2	7.314	452.2	.00944	.01587
900	0	39.782	1	10.819	1140.71	95.5	142.4	63.3	68.2	85.1	10.435	516.1	.01158	.02060
1000	0	48.199	1	29.691	1068.31	74.8	108.1	72.0	81.0	76.4	14.480	580.7	.01402	.02609
1100	0	57.732	1	50.924	1011.38	60.1	85.7	76.5	87.2	65.5	19.556	643.7	.01679	.03228
1200	1	8.379	2	14.311	964.91	48.9	70.1	88.3	104.0	62.5	25.847	706.6	.01989	.03909
1300	1	20.132	2	39.763	924.14	41.1	62.6	94.0	112.5	56.0	33.397	767.4	.02332	.04650
1400	1	32.990	3	7.422	886.67	34.9	49.6	103.5	128.8	52.5	42.335	826.8	.02705	.05457
1500	1	46.953	3	37.359	852.12	30.1	42.5	112.1	140.4	49.2	52.770	885.3	.03082	.06331
1600	2	2.039	4	9.746	820.16	26.4	36.9	123.2	156.6	47.0	64.840	943.2	.03551	.07278
1700	2	18.271	4	44.618	790.52	22.8	32.3	134.0	171.5	44.8	78.629	1000.9	.04024	.08298
1800	2	35.667	5	22.246	762.54	20.1	28.1	144.0	185.3	42.5	94.262	1058.5	.04532	.09401
1900	2	54.277	6	2.751	735.56	18.0	25.6	154.0	197.5	40.4	112.527	1118.3	.05074	.10591
2000	3	14.110	6	46.362	709.54	15.8	22.5	166.8	214.0	38.8	131.765	1174.5	.05652	.11875
2100	3	35.251	7	33.416	684.83	14.2	20.1	180.0	230.8	37.7	153.990	1233.2	.06269	.13266
2200	3	57.752	8	23.720	660.21	12.8	17.7	196.5	252.0	37.0	178.850	1292.5	.06927	.14758
2300	4	21.567	9	17.025	636.85	11.6	16.2				206.412	1352.2	.07623	.16347
2400	4	46.748	10	13.652	614.31	10.5	14.7				236.814	1411.8	.08361	.18042
2500	5	13.324	11	16.429	592.58	9.5	13.7				270.360	1470.4	.09140	.19934
2600	5	41.322	12	16.381	571.61	9.0	12.5				307.200	1531.9	.09962	.21754
2700	6	10.723	13	22.686	551.38	8.2	11.5				347.478	1592.0	.10826	.23783
2800	6	41.546	14	32.053	531.87	7.3	10.3				391.002	1652.4	.11734	.25926
2900	7	14.264	15	45.268	513.05	6.8	9.6				439.574	1714.0	.12700	.28211
3000	7	48.858	17	2.369	494.89	6.0	8.9				493.594	1776.8	.13723	.30649
3100	8	25.339	18	23.300	477.39	5.5	8.1				551.804	1840.8	.14806	.33242
5465.8*	45	00.000	68	24.510	203.57						6844.220	3432.4	1.00000	2.52690

*Extreme range of rifle.

†On assumption that gun when fired is 12 inches above ground and that the point of aim is at the middle point of an infantryman 68 inches high, or of a cavalryman 96 inches high.

**Computed from foreign data.

The application of this lies in a study of the relative sizes of a given target and a given dispersion. For if we know the size of the target and the mean dispersion at a given range we can calculate at once the percentage of probable hits, and, conversely, knowing the size of the dispersion, we can tell then what must be the size of the target that it shall be hit a given per cent of times.

In determining the size of the dispersion, the data published by the Ordnance Department for the accuracy of the rifle will of course, enable us to determine the probable mean dispersion of a single rifle with no human or other avoidable sources of error included, since the tabular mean deviation, multiplied by 1.69 (theory of probabilities) will give the probable dimensions of the dispersions at any given range. Thus if the tabular mean vertical deviation is 10 inches, and the mean horizontal deviation is 11.4 inches, then the probable mean vertical dispersion is $10 \times 1.69 = 16.9$ inches and the mean lateral dispersion is $11.4 \times 1.69 = 19.3$ inches. The results thus obtained, however, are not suited to a study of battle efficiency, because of the elimination of the human factor. To find the practical dimensions we shall have to fall back on the figures resulting from a series of experimental firings at the (German) Infantry Firing School at Spandau, where the same character of rifle and ammunition ("S" bullet) were used, and the firing was done by skilled marksmen under the most favorable conditions of light and atmosphere.

In the following discussion the dispersion thus determined has been used. In addition to the figures taken from our ordnance reports, data has been taken, and in a modified form used in preparing Table 2 from articles published in the "Bulletin de la Presse et de la Bibliographie Militares" (1906) and from the various works of Lieutenant General H. von Rohne

von Ploennies, (German), Parravicino (Italian), Paque (French) and others.

TABLE II

TABLE OF DISPERSIONS, ETC.

Distance	Angle of Fall		Tangent	Mean Dispersions (50 %)		
				Vertical	Lateral	Long'l.
Yards	°	′	(Nat.)	Inches	Inches	Yards
400		15	.004363	32.6	32.6	208
500		20	.005817	34.4	34.4	164
600		30	.008726	43.0	43.0	137
700		40	.011636	45.7	45.7	109
800		50	.014545	51.3	52.5	98.5
900	1	10	.020365	64.0	69.0	87.5
1000	1	32	.026768	73.5	82.0	76.5
1100	2	00	.034920	82.3	94.0	65.5
1200	2	28	.043078	93.5	115.0	60.2
1300	2	55	.050949	100.0	120.0	54.7
1400	3	28	.060578	115.0	143.0	52.5
1500	4	00	.069926	123.6	154.0	49.2
1600	4	45	.083093	130.0	165.0	43.7
1700	5	30	.096289	151.5	194.0	43.0
1800	6	35	.115409	172.8	223.0	41.5
1900	7	50	.137575	190.0	244.0	38.3
2000	9	00	.158384	218.0	257.0	38.0

NOTE:—This table was compiled from foreign data during the preparation of the text in the absence of similar data for the '03 model Springfield rifle. It is inserted here for reference only. A correct table for the present rifle will be found in Table III, though it will not, of course, agree with the examples worked out herein which were based on Table II.

By the use of tables 1 and 2 we may compute the probability of effect of fire under any given conditions, as is illustrated in the following examples.

Example 1. What percent of hits may be expected at 800 yards on a wall target of great breadth and 5 feet 6.5 inches high (66.5″)?

The mean vertical dispersion is, according to Table 2, 51.3 inches at 800 yards. The ratio between

this dispersion and the height of the target i. e. the "Probability Factor" is $\frac{66.5}{51.3}=1.30$.

Reference to Table 1 shows that a probability factor of 1.3 corresponds to 62 per cent of hits. This does not mean, however, that 62 per cent of hits would generally be obtained, but that it is probable that 62 per cent will be obtained if the number of cartridges fired is large and IF THE CENTER OF IMPACT LIES EXACTLY IN THE CENTER OF THE TARGET, in which case, of 100 shots fired 62 will hit the target and 19 will go over and 19 under the target. (Fig. 3) Any movement of the center of impact from the center of the target will, of course, diminish this percentage of probable hits.

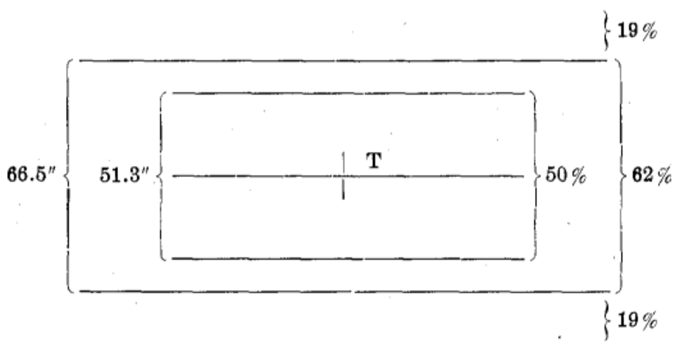


Fig. 3.

Example 2. How high must a very wide target be in order that it may receive 100 per cent of hits at 1000 yards?

The probability factor corresponding to 100 per cent is something over 4;* the target must therefore be at least 4 times as high as the mean vertical dispersion. This is 73.5 inches at 1000 yards, therefore the target must be 4×73.5 inches, or 24.5 feet high.

*P.F. 4 here used really corresponds to 99.3 per cent, not 100 per cent.

Example 3. At what distance is it probable that a very wide target 9 feet high will receive 30 per cent of all shots fired at it?

9 feet =108 inches, the probability factor for 30 per cent is 0.57; the mean vertical dispersion must be not greater than $\frac{108}{.57}$=191.5 inches. From Table 2, this is seen to be the dispersion at about 1900 yards.

In the absence of data similar to that by which the mean vertical dispersion was obtained, it becomes necessary, if one would know approximately the width of the vertical strips containing 50 per cent of the hits, to calculate them from the relation which exists between the mean vertical and horizontal deviations in the individual shot group. In this manner column 7 (Table 2) was calculated.

Example 4. What percent of hits can a target 30 inches wide receive at 1000 yards, and at 400 yards, provided it is so high that no shot can go over it?

The mean horizontal dispersion at 1000 yards is 82 inches. The probability factor is, therefore, $\frac{30}{82}$=0.368=19 per cent of hits.

The mean horizontal dispersion at 400 yards is 32.6 inches. The probability factor is, therefore $\frac{30}{32.6}$=0.92=46½ per cent of hits.

In the foregoing examples a target 4 times as wide, or 4 times as high as the given dispersion was assumed so that we needed only to consider the height or width of the target according to the example presented. Where, however, the dimensions of the target are given both in width and height, we must go one step further and, obtaining each percentage separately, mulitiply them together, thus:

Example 5. What percent of hits is probable on a target 35 inches high and 60 inches wide at 1100 yards?

The mean vertical dispersion is 82.3. The probability factor is $\frac{35}{82.3}=0.425=23$ per cent.

The mean horizontal dispersion is 94. The probability factor is $\frac{60}{94}=0.64=33$ per cent; 33 per cent $\times 23$ per cent $=7.59$ or about 8 per cent.

With the aid of Table 2, we may obtain a clear idea of the distribution of shots in the group. Draw a horizontal line through the center of impact of the group, then on each side draw parallel lines at distances apart equal to ½ the mean vertical dispersion (Fig. 4); the group will then be divided into eight strips, each pair symmetrical and receiving 25, 16, 7 and 2 per cent of hits.

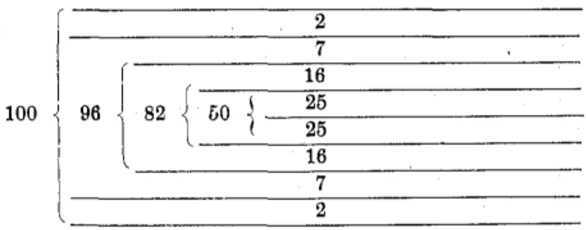
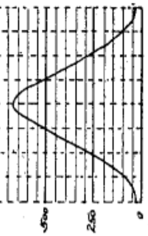
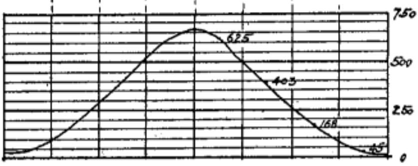


Fig. 4

If the target be similarly divided into vertical strips, it will be covered by 64 squares, the number of hits in each of which will be different and can easily be calculated. Figure 5 shows such a division of a shot group containing 10,000 shots—really only 9,852, because the factor 4 does not really correspond to 100 per cent but to 99.3 per cent; only an infinitely great factor corresponding to 100 per cent.

3	12	29	45	45	29	12	3	178
12	45	108	168	168	108	45	12	666
29	108	168	403	403	168	108	29	1600
45	168	403	625	625	403	168	45	2482
45	168	403	625	625	403	168	45	2482
29	108	168	403	403	168	108	29	1600
12	45	108	168	168	108	45	12	666
3	12	29	45	45	29	12	3	178
178	666	1600	2482	2482	1600	666	178	Totals





Probability Curve

Fig 5

It should be remembered that the above table is a table of probable hits and that its dimensions change with the accuracy of the fire, but that the figures in the squares remain the same irrespective of rifle or of marksmanship. If every bullet remained in the place where it struck, a hill or mound of bullets would be formed whose section could easily be drawn so soon as the size of the group were known. The smaller the group, the steeper would be the hillsides, and the less the prospect of hitting the target if the center of impact does not correspond to the center of the target; conversely, the larger the group the greater the chance of hitting the target, but of course with a diminished number of projectiles.

As to the causes which lead to this dispersion, it is assumed that they have been covered by the reader's elementary investigation into the trajectory of the single rifle, it is well, however, to remember that the extent of the dispersion depends principaly on the dispersion arising from the greatest sources of error, that is, of two causes of dispersion, such as variations in the initial velocity and angular errors due to faulty sighting, the extent of the dispersion will be a resultant of these two causes and that

cause, therefore, which exerts the greatest power will control the resultant to the greatest extent. This law was deduced by the French ballistician Didion and it is known as "Didion's Law." Briefly this law is, that the combined effect of two forces is equal to the square root of the sum of their squares. It is important to a proper understanding of the many problems in ballistics and the probability of hitting, but is omitted here since taking our data from the collective sheaf instead of the individual cone, diminishes the occasions for its use in our problems. It will be seen, however, that since each rifle is, in itself, subject to a dispersion about its center of impact, a number of rifles, each having its own center of impact introduces a new source of dispersion for the collective group, and if we had taken the dispersion of the single rifle instead of that of the collective sheaf we should now have to ascertain the absolute amount of the dispersion under these two sources of error.

In field firing where the individual cannot fire as calmly as at target practice, where the position is often off-hand, where a fatiguing march has, perhaps, just preceded the firing, where the targets are poorly lighted and partially hidden, where hostile shrapnel is bursting overhead etc., all the individual errors in aiming will be greatly increased. Such errors are angular ones and increase in almost direct geometrical ratio to the range and become very great at the long ranges. According to the experiments of Colonel Wolozkoi, a distinguished Russian ballistician, good shots make an angular error of ± 8 minutes, poor shots $\pm$ 40 minutes and the average of a mixed command is $\pm$ 25minutes. If, however, we assume that these errors of the firers cause a mean dispersion of only 5 minutes of arc, the mean dispersion under the combined action of rifle and erroneous

aiming would be obtained (Didion's Law) by determining the resultant of these two powers.

An error of 5 minutes in aiming causes a dispersion of 10 inches at 1000 yards. The mean vertical dispersion (Table 2) at 1000 yards is 73.5 inches, therefore E @ 1000 yards $= \sqrt{73.5^2 + 10.0^2} = 74.2$ inches.

In this manner, the effect on the dispersion of any assumed error in aiming may be determined.

The influence of the wind, if steady, has no effect on the dispersion, as it serves merely to move the centers of impact and all of them uniformly. It is, however, one of the most potent causes of error if the wind be gusty and strong as it then increases the dispersions through its erratic action on the individual trajectory.

It has been pointed out that the smaller the dispersion the greater number of hits on an object of certain size, that is, the greater chance of hitting, but only when the center of impact coincides with the center of the object. So soon as this coincidence ceases the probability of hitting decreases and the smaller the dispersion, the more rapidly does the probability decrease, for if we consider a rifle with out any dispersion, so that every shot falls in exactly the same spot, then if the center of impact lies even ¼ of an inch outside the object no hits will result, whereas with a rifle of considerable dispersion, some at least of the shots will strike the object even with an eccentrically placed center of impact.

The combination of an expert rifleman and his highly perfected rifle and ammunition is a powerful, but it is a delicate tool which requires the maximum of intelligent application on the part of its director to produce results worthy of its excellence, and it is of supreme importance that the troop leader should have a clear understanding of the extent of the dispersion to be expected in field firing, the extent of

the beaten and of the danger zones, the influence of slopes and of the influence of an eccentric position of the center of impact.

The dispersion in field firing becomes very great, varying with the training of the men, their physical condition and the mental excitement of combat etc., but quite apart from the extent of the dispersion is the influence exerted by the position of the center of impact with relation to the center of the target.

If the center of impact does not coincide with the one expected, the reason may lie in varying atmospheric conditions to a small extent; to a far greater extent will the eccentricity be due to mistakes in estimating the range. In discussing the effect of eccentricity of the center of impact, three classes of cases must be considered, viz.

1. The center of impact coincides with the center of the target.

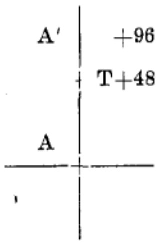
2. The center of impact falls on the edge of the target.

3. The center of impact falls outside the target.

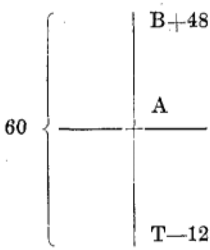
For example;—Let the target be a board fence 4 feet high and of considerable width, and the range 800 yards.

1. With the center of impact coinciding with the center of the target: The mean vertical dispersion at 800 yards is 51.3 inches, the probability factor $\frac{48}{51.3}=0.935=47$ per cent. Of the remaining shots $26\frac{1}{2}$ per cent go over and $26\frac{1}{2}$ per cent fall below the target.

2. With the center of impact on the upper edge of the target (+48″): In the space AA′ (96 inches high) will fall 79 per cent. (P.F. $=\frac{96}{51.3}=1.87=79$ per cent). In the space TA, only one half as large, 39½ per cent or say 40 per cent of hits will fall, and since the shots are grouped symmetrically about the center of impact, 10 per cent will fall below the target and 50 per cent will go over.



3. With the center of impact, say 12 inches below the lower edge of the target, (−12): In the space BT (60 inches) 44½ per cent of hits strike. In the space AT (12 inches) 12.5 per cent of hits will strike. Consequently in the space BA 32 per cent of hits may be expected. (44.5−12.5=32 per cent.)



The effect ceases altogether when the deviation of the center of impact from the center of the target is greater than 126.6 inches, that is, in the general case, when it amounts to more than the sum of half the height of the object (24 inches) and double the mean dispersion (2✕51.3), because the shot deviating farthest from the center of impact, can no longer hit the target.

Reference to a table of ordinates shows that with an elevation of 1000 yards and a target at 800 yards, the center of impact above the top of the target at 800 yards exceeds 126.6 inches, hence no result would be obtained against the target in this case.

In field firing the dispersions will, of course, be much larger and so long as the center of impact is situated within the target, there will be a loss of effect on account of the larger dispersion, but with a greater deviation in the position of the center of im-

pact, the number of hits on the target will be increased by an increased dispersion. The inference to be drawn from this is not that incorrect aiming (increased dispersion) is desirable but rather that correct placing of the center of impact is of paramount importance with the modern rifle, for a very great dispersion lowers the number of hits considerably while small dispersions and a correctly placed center of impact increases tremendously the results obtained from the firing of a certain number of cartridges.

We have shown that the results of fire are dependent 1st upon, the extent of the dispersion, and the size of the target, and 2d upon the position of the center of impact relative to the center of the target. The results are also dependent 3d, upon the curvature of the trajectory; for of two rifles, that having the highest trajectory will, by slight changes in the angle of elevation (range) vary most in the position of the center of impact.

Thus, with the old .45 Springfield Rifle an error in excess of the true range of 100 yards, would at 800 yards raise the center of impact 15.5 feet; while with the modern ('03) rifle it raises it only 7.46 feet, and with the '06 bullet considerably less than that.

The advent of the present flat trajectory rifle and ammunition was hailed as a panacea for all the ills of range-finding, since an error in elevation (range) which with the curved trajectory would throw the center of impact off the target, now would cause only a slight displacement of the center of impact. The relief afforded was more imaginary than real, however, since the very advantages claimed for it lead to a decrease in the dispersion and to a consequent increase in the necessity for a more accurate placing of the center of impact. The use of telescopic sights and other similar inventions still further decrease

the dispersion, when used, and tend to nullify the benefits of the flat trajectory. Undoubtedly the effect of the flat trajectory has been to lessen the evil results of an incorrectly estimated range, but only to a limited degree, and the difficulty of range-finding still remains a bar to really good shooting in war.

The opportunities for the use of a range finder will be limited, in war, and ranges must be guessed to a very great extent. There is no question but that training will lessen the percentage of error in "estimated range" but even the best of estimators must include a factor of error that is vital to good results in field firing. The absolute amount of this error varies, with the training of the estimator, the character of the ground, target, light etc., but it conservatively may be placed at $\frac{1}{8}$ of the range for trained men and almost anything over $\frac{1}{8}$ of the range for those imperfectly or wholly untrained.

Von Ploennies in his "*New Studies*" states that --"From a personal experience of several years as an instructor of sharpshooters, I have found that, after a special instruction of the men for one year (which was preceded by a 12 months training in the Infantry of the line), of any 100 recorded distances only about 60 are usually estimated with an approximate accuracy of 10 per cent, and only about 40 with one of 5 per cent; from which it follows that the average accuracy of the estimations is much less, even in time of peace, and that the errors in the field will, on the average, scarcely be confined to 15 per cent or 20 per cent." Lieutenant General Parravicino in an article in the "*Revista de Artiglieria*" says, that the error of estimation according to his own experiments, amounts to

50 m. at the distance 415 to 530 meters
100 m. at the distance 650 to 750 meters
150 m. at the distance 850 to 960 meters

which is an average error of $\pm \frac{1}{7}$ of the true range.

If a distance is estimated at 700 meters theoretically it is an even chance that the true distance is over 600 meters, but less than 800 meters for in ¼ of all cases the distance is less than 600 meters and in the other ¼ it is greater than 800 meters. In experiments made by Lieutenant General H. Rohne with trained men, over unknown ground the average of errors was found to be

at 520 meters 24.5 per cent
at 1000 meters 16.4 per cent
at 1450 meters 6.6 per cent.

Of 231 estimates, 12 were correct, 69 too great and 150 too small.

The average error amounted to 1/7 of the range, but in specific cases it reached as high as 54 per cent and 62 per cent of the distance. General Rhone, himself remarks on the apparent increase of accuracy at the longer ranges and accounts for it on the ground that the men passed successively from the shorter ranges by intermediate ranges to the long ones and were, therefore able to use their earlier estimates as a guide at the longer ranges. Not satisfied with the results, he conducted other exercises—this time over known ground—but with precautions against outside influences and attained an average error of 12.5 per cent, that is to say ⅛ of the range.

The report of the Senior Officer's Course held at (English) School of Musketry at Hythe 1905, gives the results of the tests for all students. Regular officers, estimating at targets none of which was more distant than 700 yards made the following errors: Correct 15 per cent. Within 100 yards = 49 per cent. Within 200 yards = 20 per cent, more than 200 yards = 14 per cent. Commenting on these results, the report states "From these figures, compiled at distances under 700 yards, it appears that fire controlled by these officers and noncommissioned

officers would be mostly wasted. The standard is about equal to that of "Slightly Trained" French officers." . . . "French Officers and soldiers tested under various conditions made the following mean errors in judging.

Fully Trained Officers 12 per cent
Slightly Trained Officers 20 per cent
Soldiers of the Active Army 30 per cent"

Remembering that these results

$\frac{1}{10}$ Von Ploennies
$\frac{1}{7}$ Parravicinco
$\frac{1}{8}$ Von Rohne
$\frac{1}{5}$ English

were attained only by trained estimators, in time of peace, and at silhouettes generally distinct and well lighted, an idea may be formed of the probable error of individual commanders, using their own estimate, rather than a mean of several estimates of trained men, and estimating over unknown ground, the distance to a moving, dimly-seen suddenly presented target. In the following discussion an error of $\frac{1}{8}$ is assumed and from the results attained with this error, one can easily imagine, or calculate the probable results under the circumstances cited, especially if the individual commander is untrained.

Since all Infantry companies, at least in the Regular Army will be supplied with range finders, it is pertinent to inquire into the effect of the use of these telemeters. Experiments conducted with the greatest care and by trained observers have shown that with our penta-prism range finder, ranges *may* be determined with an error not greater than 2 per cent. Where, however, the base is measured by pacing this minimum error increases to about 10 per cent, and under fire, over rough ground and at an indistinct target, it will be reasonable to assume an error of at least 20 per cent, and to expect one even larger. With the new *Aboue Range Finder* used by our ar-

tillery the results are much better but their use by infantry is hardly practicable. The rifle sight is graduated, except at the long ranges, in spaces representing 50 yards, so that if the range finder shows a range of say 925 yards; the firer must set his sight at 900 or 950 yards and if an error of 5 per cent has been made (target at 973 yards) the use of the 900 yards elevation would be an error of 73 yards, $=7\frac{1}{2}$ per cent. But the range does not agree, exactly, with the elevation that should be used because of the influence on the projectile of atmospheric conditions. The error when using the range finder, certainly should never equal that to be expected in an estimated range, (though in practice it often does) but because of the quite evident difficulties which will attend its use by an assaulting body of troops, it would seem highly probable that we shall still have to estimate ranges at least until a practicable range finder shall have been invented. The error of one eighth assumed in this discussion will apply also to ranges "found" by untrained men and will be usually exceeded in war when estimating is resorted to, and often when a range finder is used.

An error in estimating the range manifests itself in two ways, according as the fire is directed or not. If each of the skirmishers estimates the range for himself and uses the corresponding elevation, then the result will be a wide dispersion of the centers of impact and a corresponding loss of effect in the fire. If, on the other hand, all use the same, but an incorrect elevation, the dispersion will remain constant, but the center of impact will not coincide with the center of the object, and a loss of efficiency proportional to the eccentricity of the center of impact results.

Considering the first case: Assume a target at 800 yards, then one-half of the estimates and centers

of impact will lie between 700 and 900 yards; that is to say an even chance exists that they lie on each side of the true range and that ½ of all the estimates are within the error of ⅛ of the range and ½ exceed that error. The mean dispersion in depth of the centers of impact then is 200 yards and this corresponds to a vertical dispersion of 105 inches. The mean vertical dispersion at 800 yards when the centers of impact are coincident is 51.3 inches. Applying Didion's Law to determine the combined effect of these two sources of error we get $\sqrt{105^2+51.3^2}=117$ inches as the mean dispersion under the conditions cited.

The effect in hits of this increased dispersion will be to reduce the number of probable hits to about ½ of what might be expected with a mean vertical dispersion of 51.3 inches and a correctly placed center of impact. If a line of skirmishers, at one man per yard was fired on under the two conditions assumed, we might expect 6.55 hits in every 100 shots in the one case, but only 3.26 in the other.

So long as the mean dispersion which results from using incorrect elevations is greater than that due to individual marksmanship, as in the case just cited, it is utterly immaterial whether the men shoot well or poorly, and from this it follows that the effect in field firing at the middle and long ranges, is influenced to a far greater degree by the estimation of distance than by individual errors in aiming and firing. *Hence, to increase the effect of field firing it is necessary to increase the accuracy of estimating the distances rather than to increase the accuracy of individual fire.*

At 550 yards the probable error in estimating the distance is 68.7 yards. The mean vertical dispersion of the centers of impact is $137.4 \times \tan 25' = 36$ inches, and this almost exactly the same as the mean vertical dispersion which is assumed for well trained marks-

men in field firing. As the range becomes greater, then, than 550 yards the dispersion due to the errors in estimation increases more rapidly than does the dispersion due to errors in aiming. Beyond this range, therefore, it is time, energy and money wasted to increase the skill of the individual man unless the development in skill in estimating distances progresses a corresponding amount; and vice versa, it is useless to increase the skill in estimating distance unless the skill in marksmanship is correspondingly increased. Knowing the relative power of these two factors, stress must be laid on reducing that which produces the greatest errors.

Before considering the other phase of the question, it is well to observe that such a case as has been assumed above (every man estimating and using his own range) will usually occur at the short ranges. At the longer ranges where the men are still well in hand and the noise of the conflict not too loud, commands designating the elevation will be heard and obeyed, but in action it is certain that the command announcing the elevation will not be heard at ranges under 500 yards, so that at the short ranges where the errors of estimation exercise less effect than do errors, in aiming, no bad results will follow the dispersion of the centers of impact *so long as the men are trained to estimate distances with an error not exceeding 15 per cent.*

Considering, now, the second case, *i.e.*, a designated elevation used by all, and that elevation incorrect.

If the commander orders an elevation of 1000 yards, and his estimate of the range, or better still, his estimate of the elevation, is exactly correct, then the maximum of effect is obtained, the value of this effect being proportional to the skill of the firers, (smallness of the dispersion). If, however, an error

of $\frac{1}{8}$ is assumed (=125 yards), that is, that the target is at 875 or at 1125 yards, then with a very small dispersion, no result is obtained at all, because the cone of dispersion is so small that none of the shots can reach the target; if, on the other hand, the dispersion is greater, as it assuredly will be, then with average shots, a target wall 68 inches high at 875 yards, or at 1125 yards will receive about 5.5 per cent of hits. With poorer shots, producing say double the dispersion above considered 13 per cent of hits would be obtained. It is apparent that with only the average error of trained estimators, the poorer shots will here secure more hits than will the good shots.

The influence exerted by the estimate of the range in its relation to the character of the marksmen is clearly seen if we consider three classes, "expert", "average" and "poor" marksmen, whose dispersions will bė, according to General Rhone's observations:

Expert=$\frac{1}{2}$ the dispersion of average
Average=the dispersion of average
Poor=2 times the dispersion of average.

With an elevation of 1000 yards exactly estimated we may expect, for *average* shots 47 per cent of hits. With an error of $\frac{1}{8}$, only $5\frac{1}{2}$ per cent of hits. If instead of average marksmen we consider "*experts*" we could expect with the correct elevation 79 per cent of hits, and with an error of $\frac{1}{8}$, no hits at all. And if we consider "*poor*" shots we would get with the correct elevation 25 per cent of hits, and with the error of $\frac{1}{8}$ we would still get 13 per cent of hits.

These figures are of the greatest importance since they permit an investigation into the different causes of error and their relative effect. The maximum of effect is obtained with Experts *knowing the range exactly*, and the minimum of results is obtained by these same men with the error of $\frac{1}{8}$ in estimating the

range which is an error less than will obtain in war with any but the most highly trained estimators, and about what we may expect if we use a range finder under service conditions.

The question thus is squarely presented—"What can and must be done to produce the maximum results under service conditions?" Target practice alone will not do it, range finders alone, however accurate and convenient, will not do it, and it is evident that we must either devote more time and attention to range finding (estimating) so as to bring it up to the high standard of individual excellence we have established in shooting (on the range only, be it observed) or contenting ourselves with a mediocre and inferior standard of expected results, spend less time and money on target practice.

It is really a matter of point of view after all, for in foreign countries, where the matter has been scientifically approached, the system of target practice evolved is based wholly on service conditions, and a return for the expenditure of ammunition is looked for in an increased ability to hit in war. We, on the other hand, have spent our energy and enthusiasm in developing individual skill in musketry, by garrison training and target matches, which often defeat the very object of their existence—high percentages of hits in war, because of the false and misleading habits and ideas which they inculate, increasing, as they do, the tendency to regard target practice as a pastime, to be conducted under such conditions as will eliminate every element of difficulty or uncertainty and enable a few experts to obtain an assured return for money expended in new rifle barrels and special appliances unsuited to war. The recent changes in competition rules, however, show that the evil is appreciated and will be guarded against in the new Firing Regulations. Would it not be better at

once to recognize that it is only at ranges under 500 yards that individual errors may be assuredly pointed out and to spend the time and money now used beyond that range, teaching the direction, control and observation of fire under service conditions?

If we are properly trained in estimating distances, so that our errors will not exceed, say one-eighth of the range under service conditions, and if we train our men to the use of the range finder—occasion for the use of which *may* arise at some stage of some fight—we will have done much to increase the probability of securing an adequate result in war for all our peace training, but even then, there are two other ways of increasing the efficiency of our service fire, both of which might, under a slightly different system of target practice, be perfected in peace.

The first of these corresponds to the "bracketing" or "forking" fire of artillery and the determination of the *elevation* (rather than of the range) by observing the fall of the projectiles. The second, is to decrease the density of the cone in order to increase the dispersion and so the length of the so called danger zone, by using two or more elevations at the same time and against the same object. In either of these methods we consider the fire unit as a single weapon, just as the artillerist considers his four or six guns as a single weapon, and we will use one or the other in war as the circumstances—physical and tactical—seem to indicate as the best suited to the situation.

We can, without doubt, often observe in action whether our fire is effective or not. Men and horses are seen to fall, commotion in the hostile ranks, delay in his forward movement and a decrease in his fire will be observed, but all this will be only when our fire is so effective that it will not need correcting. If the troops are well in hand, so that a correction in

elevation may be made, the absence of these visible signs of effective fire will permit a conclusion that the fire is incorrectly placed, because if the center of impact is near the center of the object, some result will still be obtained even with a very large dispersion. If any other troops are firing at the same target at the time, all hope of observing fire is gone, but assuming that such is not the case, the question is only whether the shots are going over, or are falling short of the target.

If the ground is such that the shots may be seen striking the earth, some idea may be obtained of the direction of the error, if one rembembers about the percentage that *should* strike in front or in rear of the target with a correct elevation.

With average marksmen, the correct elevation, and a target 68″ high, we may expect at 800 yards 18.5 per cent short, 63 per cent hits, 18.5 over.

1000 yards 26.5 per cent short, 47 per cent hits, 26.5 over.

3000 yards 42 per cent short, 16 per cent hits, 42 per cent over.

To change an elevation simply because a certain number of shots are seen to fall short, or in rear of the target and none on the other side would be foolish as will be evident when we consider that the ground where the bullets are falling may be favorable to observation of the strikes while that on the other side of the target is unfavorable, and that under such circumstances more than ¼ of all the shots fired would, at 1000 yards fall short or over when the correct elevation is used.

If the character of the ground is apparently favorable to observing the fall of the projectiles, we will do much better by having one platoon fire with an elevation of, say 1200 yards, the other not firing, then having the other platoon fire at say 800 yards.

The next volleys may be so ordered as to reduce the depth of the fork or bracket, from 400 yards to say 200, by firing the first volley at 1100 yards, the second at 900, and continuing to reduce the depth of the fork until one volley is seen to strike directly in front, the other directly in rear of the target, the true elevation being a mean of those last used. This process requires time and a favorable ground for observing the fall of the bullets as well as a favorable point of observation for the conductor, who should seek such a point before commencing the fire and not attempt to conduct it from a prone position with the firers; the giving of the commands to the men should be delegated to another officer.

Such favorable chances for observing the fall of the projectiles will seldom occur and certainly no dependence can be placed on a conclusion as to the character of the error from observing the fall of a number of bullets short (or over) the target. Fork fire if practicable will be reliable, but only when properly conducted and under conditions which permit its use.

The second method of assuring some result from fire, even if a result less than the maximum, consists in causing one part of the fire unit to fire with an elevation slightly in excess of the determined range, while the other is firing with an elevation slightly less than that range. The interval between the two elevations being such that the mean dispersion of one set of firers will overlap that of the other. The result of this combination is to increase the depth of the dispersion but, of course, to diminish its density.

At 500 yards, the probable error in range is 62.5 yards; the percentage of hits to be expected on a target wall 68 inches high is 74.5 per cent, and against a line of skirmishers at one man per yard, this be-

comes 8.9 per cent with *average* shots. If we assume expert shots the percentage will decrease and with poor shots it will increase as we have seen. Since the maximum result is attained when using a single *correct* elevation, it is evident that with combined sights we will increase the percentage but little over that obtained with one elevation, for had the average shots used one elevation and that the correct one they would have obtained only 9 per cent of hits, so that with a single elevation and the usual error in the range these marksmen would still have attained almost the same results as with the correct range (loss 0.1 per cent).

If against such a target which is 550 yards away, two sights are used (500 and 600 yards), we would obtain from the 500 yard rifles 8.5 per cent and from the 600 yard rifles about 8.2 per cent of hits, that is, from the combined rifles we would expect 8.3 per cent of hits. Had the correct elevation been used, and but one elevation the percentage of hits would have been only a little greater (8.6) while with one elevation and that ⅛ in error we could have expected a little less (7.9 per cent).

Considering in the same way, the effect of combined sights at, say 800 yards, target a line of skirmishers at one man per yard, placed 800 yards from the firers.

With an error of ⅛ (=100 yards) the expected hits would be 2.9 per cent. Using the elevations (750 and 850) we would expect from the 750 yard rifles 5.1 per cent, and from the 850 yard rifles 4.9 per cent, or from the combined rifles 5 per cent of hits. This is a distinct gain over the results that might be expected from the use of one incorrect sight as shown, but it is, of course, a loss if we could compare it with the results of a correct elevation (=6.55 per cent). It is greater than would be produced by

poor shots using the correct range, from whom we would expect 3.8 per cent of hits.

The combination of average marksmen and combined sights continues to increase the relative efficiency in a constantly increasing ratio after leaving 800 yards, and this is then, the point at which the use of combined sights would first be advantageous under average conditions. If the firers are highly trained and the terrain such as to make the estimation of the range difficult, the use of combined sights might begin even sooner, say at 600 or at 700 yards.

As to the difference which should exist in the two elevations, it should be remembered that this is dependent upon the size of the cone of dispersion, since the idea to be kept in view is the covering with an effective fire a zone in the vicinity of the target which is equal in depth to the probable error of estimation. The size of the mean vertical dispersion will undoubtedly increase in war beyond that here assumed, and with it will increase the zone covered by any one elevation, but this changing factor is met by the increased error in estimating distance under the mental and physical strain of war. The peace deductions as to the difference in the elevation to be ordered will still remain a safe guide in war, especially since no attempt is made to alter the elevations by intervals less than 100 yards at any range.

Von Rohne likens firing with only one elevation to "a lottery in which, besides a great number of blanks, there is a large capital prize that will make its winner independently wealthy for life; firing with two elevations to a lottery in which there is no capital prize, but which has much fewer blanks and a considerable number of quite acceptable prizes". In war it is not a question of a maximum (and exceedingly uncertain) effect, but of a reasonably certain satisfactory effect.

The fundamental principle of artillery fire—the renouncing of the greatest possible effect in favor of a lesser, but a certain one, must also be adopted by the infantry, for if the artillery, which everyone confesses has the best opportunity for determining the exact elevation, still feels the necessity for firing with two elevations differing by 100 yards in order to increase the depth of the fire swept zone, surely the infantry firing with a "guessed" elevation and unable to observe the fall of the projectiles cannot afford to put "all of its eggs in one basket."

The ultimate measure of efficiency in field firing is not the percentage of hits, nor even the number of hits, but is the number of figures disabled in a given space of time. The maximum of effect is, therefore, reached by combining close shooting, accurate ranging, proper distribution and rapidity of fire. Rapid fire will accomplish as much as slow fire in a shorter time, but with a greater expenditure of ammunition; it therefore needs justification at all times, but it will be used in the crisis, both because it will be necessary and because the excitement and confusion will be so great as to destroy the last vestige of fire discipline.

The rapidity of fire that may be attained without loss of accuracy depends directly upon the peace training of the trooops. With our system of expansive units, whereby a handful of men in each company forms the basis about which is built up in time of war a large body of untrained men, we may be assured that the rapidity of fire that may be attained in war will be appreciably less than that to which we are accustomed in peace, for any attempt by such a composite unit to approach the speed of the trained men will lead to a disastrous waste of ammunition, so that the average rapidity of the unit will generally be the rapidity attainable by the untrained.

In addition to the influence on rapidity of fire of

this peace training will be the size, color and distance of the target, for the distance not only makes necessary more time in aiming, but as the distance increases the position of the firer becomes more and more strained, the target more and more difficult to see and to hit and the calmer mental state of the firer induces refinements in sighting that would be impossible at the short ranges where the influence of the impending crisis would urge him to his maximum of speed.

Experiments under service conditions have been made in nearly every country, and the reports of these experiments show results which vary within very wide limits. A comparison of these reports is instructive. Von Rohne, in "Field Firing of Infantry and Artillery" gives it as his opinion that the following rates of fire are possible without sensible loss of percentages:

At 400 M. and under		5	shots	per	min.	per	rifle.
At 400 M. to	700	4-5	"	"	"	"	"
700	" 1000	3-4	"	"	"	"	"
1000	" 1300	2-3	"	"	"	"	"
1300	" 1500	1-2	"	"	"	"	"
Over 1500 M.		1	"	"	"	"	"

Lieutenant Colonel Baron von Lichtenstern considers these rates too high and says they will result in poor shooting and a diminished result in hits. The Italian General Parravicino, on the other hand assumes a rapidity of fire as high as 12 shots per rifle per minute using the magazine. Other observers have adopted results at varying rates between these extremes. Germany trains her soldiers to fire at speeds from 3 to 8 shots per minute according to the range The French use sudden and short bursts of rapid fire (rafales) and fix no limit on the rapidity. Degtyareff, who with Manchurian experience has written on this subject, says "We suffered much from lack of training in rapid fire. . . . . On an average 15 to 18

shots may be fired''. It is probable that this divergence of views is due to different ideas as to the point where a further increase of rapidity will so enlarge the dispersion as to nullify the advantage gained by firing more shots in a given time. It is also probable that some of the difference is due to differing methods of determining the rapidity in experiments.

It can easily be proved that up to a certain point the rapidity may be increased and the accuracy consequently lowered without decreasing the efficacy of of the fire. According to the Italian Firing Regulations, there was attained in experimental firing in that army with the exact elevation and a rapidity of fire 12 to 14 shots per minute for each rifle, about 2-3 of the percentages of hits that would have resulted with a rapidity of from 5 to 6 shots per minute. According to this, the effects of ''Fire at Will'' would be to those of ''Rapid Fire'' as 1 :1.5, but so soon as the range is incorrectly estimated, the per cent of hits in rapid fire increases because of the larger dispersion. If we assume the rate of fire to double the dispersion, then against a line of skirmishers at one man per yard, a true distance of 1000 yards and an estimated range ⅛ smaller, (or 875 yards), we would have, for average marksmen firing at the rate of

5— 6 shots per minute 4.35 per cent of hits.
12—14 " " " 4.75 " " " "

That is, for 100 men firing at the above rates for one minute, the ''fire at will'' will produce 24 hits, while the rapid fire would produce 61.4 hits.

If the elevation differs by more than ⅛ the relative efficiency of the more dispersed firing increases still more, until the smaller dispersion obtains no hits at all and the ''Rapid Fire'' (larger dispersion) is still obtaining a few. The danger of rapid fire lies in the enormous expenditure of ammunition which it involves, but on the other hand the duration of rapid

fire in combat is always short, while to still further offset the number of cartridges expended will come long periods of moderate fire or of no firing at all. Opportunities will arise during the fight, when a favorable target appears, and necessity will at other times demand—as in repulsing a cavalry charge—a vertible whirlwind (rafale) of fire, and such moments justify the expenditure of as much ammunition as is necessary to seize the opportunity or to ward off the danger. Nothing shows more clearly the difference between disciplined and undisciplined troops than their expenditure of ammunition when considering a long period of time. Captain Soloviev states, for instance, "Slow fire we never used; my regiment fired 630 rounds per man at Liaoang." While Japanese officers have stated that 150 rounds per man are sufficient for a day's fighting.

In considering a single marksman, the rate of fire becomes quite high as evidenced by our own Ordnance publications which state that "23 aimed shots have been fired in one minute with this rifle, and 25 shots in the same time, using the magazine fire." The lack of information as to the range, and the resulting dispersions, however, robs the statement of much of the value that might be attached to so surprising a rate of fire. On the other hand, considering a *body* of troops, the rate of fire per rifle, per minute becomes sensibly slower. For instance, a company of infantry at field firing. The command for firing is given and a few scattering shots respond, then, after a lapse of ten or even twenty seconds the volumn of the fire increases to a steady roll. The cease firing whistle sounds, those in the immediate vicinity of the leader stop, those on the flanks stop only after a few seconds have elapsed. The rapidity of fire per rifle, per minute is then computed from the known number of rifles, the amount of ammunition expen-

ded and the duration of the fire—that it will be less than that attained by many of the men as individuals is evident.

The most logical measure of effect is not the number of shots per rifle per minute, but the number of hits attained in one minute by 100 firers. Nor is it sufficient to know only the number of hits, but rather should one know the number of figures hit, for if a whole company should direct its fire on the same squad of an advancing line, the number of hits might be quite large, but the number of disabled men would be relatively small, because many of them would have been hit a great number of times, while the other men in the company are not hit at all. As it is quite useless to hit the same man a number of times, it is evident that the end desired—the disabling of the greatest number—can be attained only by distributing the fire along the whole front, thus distributing the centers of impact horizontally and increasing the dispersion of the shots in the same direction. It should be remembered that a positive relation exists between the width of the target and the number of cartridges fired and that the density of the firing line is relatively immaterial. For, with the same expenditure of cartridges, the percentage of figures hit (not of hits) depends entirely upon the width of the target; and, conversely, for a given width of target, the percentage of disabled figures depends entirely upon the expenditure of cartridges. The importance of this lies in the ability to determine the number of cartridges necessary to attain a certain percent of disabled figures for a given width of target and for a given range, and from this to deduce the length of time necessary to produce that effect, or the number of shots per rifle.*

Indirect firing by infantry, at least in the sense

*This distribution of fire is discussed more fully in Chapter IV under "Fire Direction".

of firing at an unseen target by the aid of an auxiliary target, will be of so little use in field warfare that it will not be discussed, but it should be remembered that infantry will often be called upon to fire at an unseen target, such as reserves on a hidden slope, and this form of indirect fire (the English call it "unaimed" fire) will not be wholly unknown, but the use of even such fire will be so unusual that the discussion of it under the influence of slopes is deemed sufficient.

One of the most potent factors in the probability of hitting is the character of the ground upon which the target stands, and this factor manifests itself in many ways.

Ricochets.—It depends upon the nature of the soil whether many or few shots, after striking, will go still farther and hit the target as ricochets. If the ground is even and solid—as on short grass—or is gently sloping from the line of sight, the shots rebound on impact, generally at a greater angle than that at which they struck the ground. If the ground rises in front of the target, or it is soft or uneven—as plowed ground—the ricochets become fewer in number, but the absolute number in a concrete case is dependent upon chance. It may generally be estimated that for 100 direct hits 20 ricochets will be obtained if the ground is not wholly unfavorable, so that, of 120 hits, 20, or 16.7 per cent will be ricochets. Of course the fixing of such a percentage of ricochets is almost arbitrary, but a number of experiments have been conducted abroad which confirm this assumed percentage; thus the Italians (Parravicino) have observed 22 per cent, and in Switzerland the percentage observed in a series of trials was 15 per cent. The different character of the soil in Italy and in Switzerland and the steep slopes over which the Swiss usually fire would account for this differ-

ence, while for our rifle and average terrain 16.7 per cent is probably nearly correct.

Danger Zone.—There are almost as many kinds of "danger zones" as there are ballisticians, hence it is unwise to accept any given table containing such zones without a clear understanding of exactly which kind of a danger zone is meant by the author of the table.

For instance, one author will mean by the term "danger zone" that area or zone wherein the mean trajectory is within the height of the object considered (Infantrymen, Cavalrymen, etc.) Another, using the same term will mean the area or zone wherein the whole cone of dispersion is within the height of the object. Still others consider the danger zone as the space wherein any part of the cone would strike the object, or where any part of the nucleus (mean dispersion) would strike it, etc.

If the author of the table explains the particular basis upon which it is computed, the the table will be useful, otherwise it will be too indefinite for scientific purposes. The trouble, doubtless is due to the inadequacy of the English language, as is evidenced when authors attempt to classify the various kinds of danger zones as "practical danger zone", "theoretical danger zone" etc. The Germans suffer from the same trouble with their terminology, and the French seen to be about the only ones who have a well understood term for at least two of the different classes of danger zones, their always precise language presenting less of a bar to acceptable descriptive terms. In the following pages, unless specially mentioned the term "danger zone" will be used to mean that zone or area wherein the mean trajectory at no place is higher than the height of the given object. This rule is adopted because of the convenience of discussion and comparison, and because with

the danger zone of the mean trajectory established all other data may easily be calculated.

In calculating the danger zone, it is customary, so long as the angle of fall is small, to consider the last element of the trajectory as a straight line. Since all parts of the trajectory are curved, this introduces a small error and tends to give danger zones in excess of that obtained when the curved nature of the trajectory is considered in calculations. Dealing, as we are here with the theory of the effect of fire rather than with the theory of ballistics, we well assume that within the danger zone the trajectory is a straight line.

Reference to Fig. 6 will show that if b represents the danger zone on level ground, b″ the zone on rising ground will be shorter, and b′ the zone on falling ground will be longer than b.

In the figure, let—

AB=the danger zone on level ground					(b)
AC= "	"	"	on rising	"	(b″)
AD= "	"	"	on falling	"	(b′)

Also let—

f=angle of fall, and
g=angle of slope.

Then, from the figure—

$$b'' : b :: \sin. f : \{\sin. 180^\circ - (f+g)\}$$
$$= \sin. f : \sin. (f.+g), \text{ consequently}$$
$$b'' = \frac{\sin. f}{\sin. (f+g)} \times b, \text{ or for small angles}$$
$$= \frac{f}{f+g} \times b.$$

Also, from the figure—

$$b' : b :: \sin. (180^\circ - f) : (f-g)$$
$$= \sin. f : \sin. (f-g), \text{ consequently}$$
$$b' = \frac{\sin. f}{\sin. (f-g)} \times b, \text{ or for small angles}$$
$$= \frac{f}{f-g} \times b$$

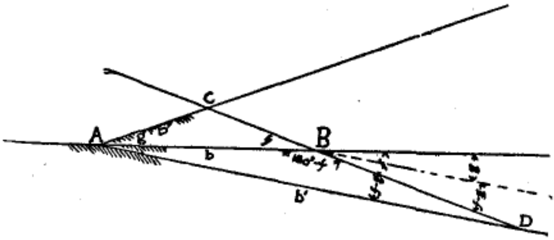


Fig 6

Example: At 1100 yards f=2°. If the ground rises 1° at the object, the danger zone AC becomes $\frac{2}{3}$ b and since, from a table of danger zones, one sees that against a target 5′6″ high a danger zone 55 yards in depth exists on level ground at the range of 1100 yards, it is at once apparent that in the case assumed the danger zone will be $\frac{2}{3}$ of 55 yards or about 37 yards.

If, on the other hand, the ground slopes downward with reference to the line of sight at an angle of 1°, the danger zone becomes $\frac{2}{1}$ b=2b, or 110 yards. If the ground falls away at a 2° slope, the trajectory which has the same angle of fall would be parallel to the ground and would eventually strike the ground only because it is really a curved line instead of the straight line we have assumed it to be.

If the ground slopes downward at a greater angle than 2°, then a low object at a short distance beyond 1100 yards would not be hit at all. (Fig. 7)

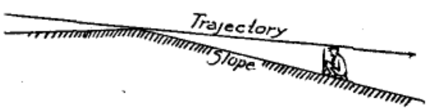


Fig 7

If we assume the angle of fall to be 1° and the slope to be 2°, then on rising ground, the danger zone becomes $\frac{1}{1+2}=\frac{1}{3}\times$b; while at a greater range where the angle of fall becomes, say 5°, then, on a

rising slope of 2° the danger zone becomes $\frac{5}{5+2}=\frac{5}{7}$. It will be seen that at the short range the inclination of the ground meant a lessening of the depth of the danger zone (and of dispersion) of $\frac{2}{3}$, while at the longer range the lessening effect is only $\frac{2}{7}$. Again, using the same slope, but on falling ground; a 1° angle of fall becomes, $\frac{1}{1-2}$ or an infinite increase (forming a dead space). A 2° angle of fall becomes $\frac{2}{2-2}=\infty\times b$ ("theoretically" an infinite swept zone). A 5° angle of fall becomes $\frac{5}{5-2}=\frac{5}{3}\times b$ an increase of $\frac{2}{3}$ over b. Here, again at the short ranges the slopes are more influential than at the long ranges.

These figures show that the influence of the terrain is more important as the trajectory is more rasant, and that this influence will be greater at short than long distances, and that the modern flat trajectory has increased the influence of sloping ground. An example will illustrate the practical value of the foregoing: Let a line of skirmishers be standing exposed at 800 yards to the fire of average marksmen employing the exact elevation. At 100 yards in rear, on a plain, is the support.

At the point where the support is stationed, it is included in the cone of dispersion whose density at this place is equal to about 0.4 of the density of the cone at the target. If the supports were 200 yards in rear, the density would be reduced to 0.026 of that of the firing line. If the ground rises 1°, the depth of the zone is reduced ($\frac{1}{1+1}=\frac{1}{2}$) one half, and the density of the cone at the supports 100 yards in rear becomes .026, while at 200 yards in rear it is missed entirely. That is, the effect of the fire, so far as the supports are concerned is exactly $\frac{1}{2}$ of what it would be on a level plain.

On the other hand, if the slope is descending at 1°, the depth of the zone becomes ($\frac{1}{1-1}$) or infinitely great, and theoretically the supports at any dis-

tance in rear would be hit as many times as the firing line. It is apparent that the configuration of the ground exercises a great influence over the efficacy of a fire directed upon a firing line and striking among echelons placed in rear, and this with a slope of only 1°, which is scarcely perceptible to the eye. Figure 8 shows the effect with average marksmen against a target 1 yard high, sights set at 1100 yards (angle of fall 2°) and against similar targets 50, 100, 150, etc., yards in rear, over horizontal ground, ascending 2° and descending 1°. The vertical lines in the figure show the distances in yards, the figures the relative density at the several points.

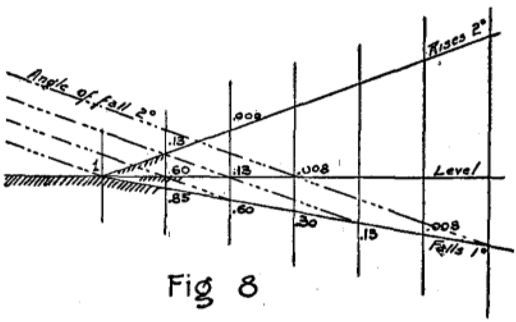


Fig 8

A target 36″ high will receive 23 per cent of hits with a correctly placed center of impact ($\frac{36}{82.3} = 0.435$ =23 per cent). The target aimed at would receive 23 per cent of hits, another target 100 yards in rear of it on level ground would receive 3 per cent; on an ascending slope of 2° no hits would reach the rear target, while on descending ground (slope 1°) a target 100 yards in rear would receive 13.8 per cent of the shots.

A thorough acquaintance with the terrain is, therefore, for the tactician, a matter of very great importance. The solution of the often discussed question of hill positions "on the crest or at the foot

of the slope'' is intimately connected with this subject. And he who decides on the placing of troops based on a ''conviction'' rather than on a study of the slopes and ranges involved will often invite defeat.

To the tactician, then, the influence of slopes is a factor which steadily increases with the perfection of weapons and which demands a very considerable study. For instance, if a firing line is posted on a front slope of a ridge with a steep slope in rear, and if the nucleus of the hostile fire strikes in the firing line, the supporting troops may be brought closer than would be possible if the firing line were posted on a plain. If the firing line is on the crest, with a gentle slope in rear, the supports must be farther away than on a plain, or they must be placed to one side of the firing line, because the shots which pass through the firing line will sweep the slope in rear for a great distance. If, however, the ground slopes away at an angle greater than the angle of fall, the rear echelons may be brought up close to the firing line as has been stated, and still be perfectly protected against infantry fire, because every shot which passes through or over the skirmishers will also go over the supports.

It is thus evident, from the point of view of the attacker, that a thorough preparation for the attack by infantry fire alone against positions on heights is difficult, because of the little searching power of the flat trajectory rifle. With artillery, however, the lower part of the cone of dispersion will usually sweep the reverse slopes and strike the hostile reserves placed thereon. The position on the slope, however, is unfavorable to artillery action in that it does not permit an observation of the fall of the shrapnel; and artillery fire directed against either the firing line or the reverse slopes will be much diminished in value

and density, because of the necessity for a great dispersion in such cases.

Probably no other country has devoted so much attention to the study of the effect of fire against slopes as has France. The conclusions, embodied in the French Firing Regulations, are to be found quoted in the Firing Regulations of nearly every other power.

The French ballisticians and tacticians have added greatly to the knowledge of the world, both in books devoted to the subject and in pamphlets and in articles in current magazines, such as the series of articles which have appeared from time to time in the "Journal des Sciences Militaires", which treat of the preparation of the attack of heights and of their defense. The following figures will illustrate the modern French views on the subject:

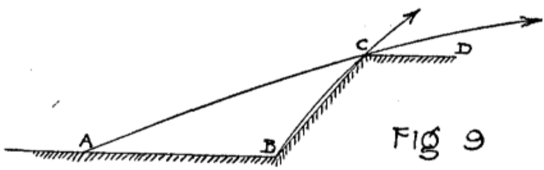


FIG 9

If CD is a plateau which is to be kept under fire, it will in most cases not be possible, on account of the flatness of the trajectory, to obtain a grazing fire from the point B, situated close by, whereas it can very well be obtained from a more remote point. If, for instance, the plateau is 25 (50 and 100) feet high, it will be swept by a grazing fire if this is opened from A on C at a distance of 550 (750 and 1000) yards with an elevation corresponding to the distance AC. This will be seen to be true by reference to a table of "Summits" for the '03 rifle. The extent of the grazed zone CD is 500 yards; for 550 yards from C toward A the angle of site is $+1^\circ$, the angle of fall of CD with reference to this line is -1°; the angle

of fall of the trajectory at 550 yards is 30′, therefore, the angle of departure beyond C equals +30′.

Such an angle of departure corresponds to a "Summit" 3 feet high and a range of 500 yards.

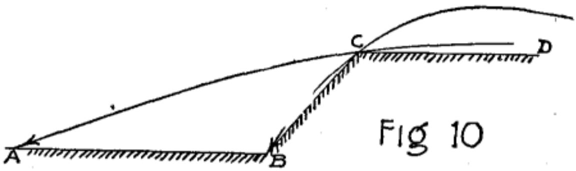


Fig 10

If CD is a plateau to be defended, the slope BC will best be swept, if the distance CD is so chosen that its angle of fall is approximately equal to the angle of slope BC. For a slope of 1° (2° and 5°) CD would correspond to a distance of 850 (1000 and 1640) yards. If a greater distance is chosen, every shot would go over C and also over the slope BC. In practice, of course, an absolute knowledge of slopes etc., would be unattainable and would, moreover, be of constantly changing value; and there would be a prohibitive element of danger in firing over the advancing troops. It is well, however, to understand these undoubtedly correct principles in order that such an application of them may be made as the condition of any given field problem may permit, as in preparation for the attack etc.

Hitherto we have discussed the effect of the rifle against target walls (solid surfaces) and have shown that the effect depends on the extent of the dispersion and the position of the center of impact. In combat we will not have solid targets, but lines of varying density made up of individual men with spaces between. Neither whould the fire be directed at certain points but rather at the whole line, thus causing a great dispersion of the centers of impact and consequently of the resulting shot group. If a line of targets (silhouettes) be placed against the solid

target which we have been considering, then only a portion of the hits will pass through (i.e. hit) the figures while others will pass between the figures and the number of such hits on the figures will be to the total number of hits on the solid background as the sum of the vulnerable area is to the area of the screen.

If we except the photogrammetic measurements of the Italian investigators as representing the vulnerable surface of a man, and for a horse, we shall have the following approximate figures, for

Inf. soldier standing, from the front	740	sq. inches.
,, ,, ,, ,, ,, side	434	,, ,,
,, ,, kneeling, ,, ,, front	530	,, ,,
,, ,, lying down ,, ,, ,,	250	,, ,,
,, ,, ,, ,, not firing	185	,, ,,
Horse, from the front	1295	,, ,,
,, ,, ,, side	3465	,, ,,
,, and rider from the front	1750	,, ,,
,, ,, ,, ,, ,, side	2795	,, ,,

In the following disscussion, these figures will be used as a basis, though they will not in every case be absolutely true, as for instance, where a man lying down is considered, for the vulnerable surface of such a target, depending on the slope of the ground, and the angle of fall of the bullets, will present a vulnerable surface in excess of that here given and in a varying degree. For example, the vulnerable area of a man lying down in the open is 250 square inches, and if the trajectory were horizontal, and the man on level ground, this would represent his theoretical vulnerable surface. But if the trajectory makes an angle with the horizontal then the vulnerable surface will be increased. Thus, Fig. 11.

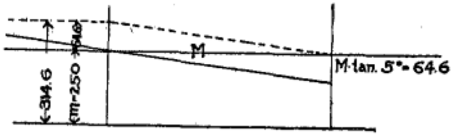


Fig 11

If m = the vulnerable area on level ground and with horizontal trajectory, = 250 square inches, and M = the vulnerable area of a standing man = 740 sq inches, then the projection of m in a vertical plane when the angle of fall is 5° will be $M_v = m + M$ tan. $5° = 250 +$ 740 tan. $5° = 250 + 64.6 = 314.6$ sq. in. So that, if the angle of fall be 2°, as at 1100 yards, and figure lie on an upward slope of 3°, its vulnerable area will be ¼ greater than it would be on a plain and at a short range where the trajectory is practically horizontal. The data thus obtained is, of course, not precise, but it affords a means of comparing the vulnerability of men in different positions. It shows for example, that the vulnerable surface of a man standing is not 3 times as great as one lying down, but only 2.35 times as great (in the case worked out) and that a mere comparison of the tabular areas (740—250 or 1: 3) would be misleading.

Suppose that on a target wall 68 inches high, one hundred hits may be expected, then if the wall is covered with figure targets so placed as to represent Infantry in close order (single rank), each would occupy a width of 26 inches (Inf. D. R.) so that in a strip of the wall $26'' \times 68''$ (=1768 sq, in.) 740 sq. in. would be vulnerable, and the hits in the target would be to the hits on the wall and target as 740 is to 1768 or as .418:1. That is, of the 100 hits expected on the target wall only $0.418 \times 100 = 41.8$ would be hits on the figures, while 58.2 would go through the intervals. If the figures were so placed as to represent a line of skirmishers at one man per yard, there would

be one figure in each strip of 36 inches×68 inches= 2448 sq. inches, and the number of hits on the figures would be $100 \times \frac{740}{2448} = 100 \times 0.302 = 30.2$ hits while 69.8 shots would go throgh the intervals.

If the figures were so placed as to represent a line of skirmishers at two pace intervals, there would be one figure in each strip of 82″×68″=5576 square inches, and the number of hits on the figures would be $100 \times \frac{740}{5576} = 100 \times .1325 = 13.25$ hits, 86.75 shots passing through the intervals. A review of the above shows that with uniformly good shooting very different results are obtained according to the target, for although less than $\frac{1}{3}$ of the number of shots fired are hits, (in the last case), the shooting is exactly as good as in the first.

The dispersion in field firing will be greater than that hitherto considered, because the errors in aiming will be greater, due to the disturbing influences which surround the firers. To a large degree the extent of this increased dispersion will be due to the lack of training in the men. It will be very great with recruits and be much less in companies largely composed of seasoned men and trained marksmen. The presence of the enemy will, in itself, increase the dispersion. But it should be observed that while at the long ranges, when the enemy is still afar off and the danger less, the men will retain a certain amount of calmness; the near approach of the hostile lines and the increased danger will cause the dispersion for a given class of soldiers to be greatly increased. Thus the natural tendency to a decreased dispersion at the shorter ranges will be neutralized by a greater dispersion, due to what the English very aptly call "Nerves".

We have already shown how to calculate the percentage of hits on a wall target, of given size and at the various ranges; combining this with the above

discussion of figure targets enables us to calculate the probable effect on battle targets.

For a firing line at one man per yard, standing, kneeling and lying down, the ratios of vulnerable surface to target wall are found as follows:

Standing: 36″×68″=2448 sq. in., vulnerabe surface $\frac{740}{2448}$=.302.

Kneeling: 36″×44″=1584 sq. in., vulnerable surface $\frac{530}{1584}$=.334.

Lying: 36″×18″=648 sq. in., vulnerable surface $\frac{250}{648}$=.368.

Lying but not firing: 36″×14″=504 sq. in., vulnerable surface, $\frac{185}{504}$=.368.

Example: At 800 yards what hits may be expected with average marksmen (exact range) against the above targets?

At 800 yds. the M.V.D.=51.3 inches. The P.F. $=\frac{68}{51.3}$=1.3=62 per cent.

At 800 yds. the M.H.D.=52.5 inches. The P.F. $=\frac{36}{52.5}$=.685=35 per cent.

The number of hits expected on a target wall 36″×68″ is 62×35=21.7 per cent.

The number of hits expected on the skirmish line standing is 21.7×.302=6.55.

Again, considering the kneeling figures:

M.V.D.=51.3. P.F.= $\frac{44}{51.3}$=.86=44 per cent.

M.H.D.=52.5. P.F.= $\frac{36}{52.5}$=.69=36 per cent.

On a wall 35″×44″=35×44=13 per cent×.334= 4.35 per cent.

On figures lying in the open:

M.V.D.=51.3. P.F.=$\frac{18}{51.3}$=.35=18 per cent.

M.H.D.=52.5. P.F.=$\frac{36}{52.5}$=.69=36 per cent.

On a wall 36″×18″=18×36=6.5 per cent×.386 =2.51 per cent.

On figures lying but not firing:

M.V.D.=51.3. P.F.=$\frac{14}{51.3}$=.27=14 per cent.

M.H.D. $=52.5$. P.F. $= \frac{36}{52.5} = .69 = 36$ per cent.

On wall $36'' \times 14'' = 14 \times 36 = 5.05$ per cent $\times .368 =$ 1.86 per cent.

These figures presume a center of impact correctly placed, which, as has been shown, will seldom occur in field firing, because of the difficulties of knowing the range exactly.

In the preceding pages, discussion of dispersions, incorrect elevations and combined sights has inevitably brought out the danger that attends high efficiency in range firing when not supplemented by as high efficiency in determining elevations, and from the discussions it may be inferred that after all, excellence in marksmanship is undesirable. This, however, is not at all true, for the confidence bred of good range firing bears fruit in war and limits the very natural tendency to wide dispersions, holding them within the dimensions which make any results at all practicable. Uninstructed men, in the excitement of combat, ignorant of the effects of incorrect aiming, will scarcely bring their rifles to the aiming position and the shot group they produce will have such huge and erratic proportions that all the skill of the commander will avail nothing toward producing an efficient fire.

CHAPTER IV

Victory in battle almost entirely depends upon a locally obtained fire superiority. Without this superiority the defense cannot maintain its position nor stop the advance of a resolute foe and the attack is foredoomed to failure because of the inability of the attacking troops to reach the defender's trenches. Having once obtained the supremacy and given the skill and moral strength to maintain it, victory is assured.

In the preceding pages we have seen how the effect of fire is modified by various circumstances and how its probable value can be computed. Let us now see how these theories are applied in practice; how the all important fire superiority is gained and how it is maintained.

The subject of the use of fire in battle—"Fire Tactics" is so closely interwoven with the subject of battle tactics that any attempt to separate the two is sure to result in an emasculated and incomplete presentation of the one or the other. No attempt will be made to discuss "Fire Tactics" in this pamphlet other than to present certain broad principles concerning the use of the rifle in war which have an almost general application.

In the earlier stages of an attack a close coöperation between the infantry and the artillery will be observed. Whether the artillery shall prepare for the infantry attack by concentrating a heavy fire on the hostile trenches as formerly will be determined by tactical considerations and a due regard for probable effect as balanced against the consumption of ammunition.

Because of the flatness of the trajectory and the relatively small dispersion of the shrapnel used, artillery fire against men in deep and narrow trenches becomes practically impotent so long as the men remain below the surface of the ground. So soon, however, as the men rise to fire they present a target sufficiently large in view of the precision of the modern quick firing gun and its tremendous destructive capacity to warrant opening fire on the men so exposed. The accuracy of the artillery fire is so much greater than that of rifle fire at long ranges that a relatively few guns will produce as many hits as a great number of rifles, therefore when the attack is first formed, the artillery of the attacker will be relied upon to permit his infantry to advance to a range where infantry fire begins to be really effective and where, as a consequence, the defender's fire from his trenches inflicts losses too grave to be ignored. This has the effect of stopping the advancing line and its further progress will only be possible when the effect of the hostile fire becomes less. Two factors which lessen the effect of infantry fire may now be applied to reduce the effect of the hostile fire, viz:—

1. To reduce the number of rifles with which he is firing.

2. To increase the dispersions of the rifles with which he shoots.

Both of these factors are brought into being by the same means, for if the fire of both infantry and artillery is concentrated on the trenches some of the firers will be killed and others will be too timid to expose themselves to fire, hence by this means the number of rifles firing is reduced. Some of the more courageous and better disciplined men will still rise to fire, but not, however, with their accustomed calmness, and the angular errors which

their excitement and sense of danger invoke will increase their dispersions to an extent which will admit of another forward movement of the attacking line. At just what range the attacking line will open fire is, thus, dependent upon so many casual conditions as to make any rule absolutely useless. One can only examine the conditions involved and deduce the solution of any given set of conditions. The result sought is so to reduce the effect of the hostile fire as to permit the attacking troops to advance up to the trenches; and in general this result is attained by first bringing a converging fire upon the position either by oblique fire, or enveloping fire; then smothering the enemy with a rapid fire of the greatest intensity and finally resorting to the bayonet and shock action if he still remains in his trenches to receive the charge. Let us consider the first of these—the converging fire.

THE FIRE FIGHT

There are three factors in Infantry Fire—The Execution, The Control and The Direction. The first of these—execution, belongs to the rank and file; the second—control, belongs to the leaders of fire units, while the third—direction, is the province of the commander of the combined fire units. Cases of absolute necessity may arise which will require the duties of control and direction to be performed by one person, but it is only in such exceptional cases that this should take place.

He who controls fire, already has a sufficiently difficult task. He must keep calm when all about him are excited, and he must transmit the sense of this calmness to his men, by word, voice, gesture and general bearing. He must indicate to the men, the elevation to be used, the objective, the point of aim, and the character and duration of the fire. These are all important duties and the officer charged with

the control of the fire of his unit must perform each duty with careful and painstaking thoroughness.

The director, unhampered and relieved of the direct control can devote his whole attention to the enemy and to the effect of the fire. With binoculars searching the ground, he picks up and designates the objective. He determines the elevation and the kind of fire to be used, and the time of commencing, and ceasing fire. He studies the results of the fire and from his observations causes the sights to be raised or lowered, alterations to be made in the point of aim and is directly responsible that fire is never opened unless the probable effect will justify the consumption of the ammunition. It is therefore, a fundamental principle that whenever fire is begun there must be one chief to control, and another to direct and that nothing but absolute necessity justifies a departure from this rule.

In the battalion, the Major will indicate the part of the hostile line upon which the fire of his battalion is to be directed. The captains will *direct* the fire of their companies, while the lieutenants will *control* the fire of their platoons. All officers, in order that they may intelligently perform their duties should be familiar with the principles governing the use of fire, the probable results of the fire and the manner of estimating the results achieved.

All fire is effective or the reverse according as it is or is not properly executed, controlled and directed. Proper execution depends upon individual skill and upon fire discipline, and neither of these can be learned on the battle-field, rather do they require much patient and intelligent work in time of peace. Of the two, the subject of fire discipline is immeasurably more important than is individual skill in marksmanship, for given a body of men however skillful in range shooting but not amenable to fire discipline

and all the control and direction in the world cannot make up for the deficiency, while given a body of men who will respond to the will of their commander and who have fired enough on the range and in field firing to know how to aim, hold and fire correctly, and these men under skillful control and direction, will produce a decidedly efficient fire in battle.

To produce these good results it is necessary that the individual errors of the firer, due to aiming, holding and pulling the trigger should be reduced to a minimum, that the soldier shall have fired enough to have acquired a confidence in his ability to hit the object at which he aims, and that he shall have acquired manual dexterity in rapid loading, aiming and firing. It is not necessary that he should know the refinements of rifle firing such as the number of points of windage and of elevation necessary to convert a 5 o'clock "outer" into a "center" at 600 yards, but it is absolutely necessary that he shall have received sufficient instruction in fire discipline to insure cöoperation and obedience on the battlefield.

Now Fire Discipline is different from any other kind of discipline and it is vastly more important, and much more difficult to instil into the soldier.

Obedience to a command may be the result either of a mental or of a physical process, usually the former; the mind receives the impression imparted by the order and by a mental process compels the muscles to obey. Such is the obedience which results from ordinary discipline, but, on the other hand, without any conscious mental activity the very muscles may instinctively obey the word of command and such is the obedience resulting from proper fire discipline.

This is necessary because in the heat of the battle, the average man fires on in an almost cataleptic state, his mind incapable of ordinary obedience.

Obedience under such conditions must, therefore, be instinctive and the result of long continued habit. This habit can only be learned by a *strict* close order drill on the parade ground, which is the foundation of fire discipline. The greater the smartness insisted upon in performing the motions of holding the head erect, handling the rifle, marching and turning, the greater will be the habit of instinctive and instant obedience acquired by the muscles. Every single individual soldier without exception should be taught and required to execute the various motions in exact accordance with the book and with the greatest smartness, always and everywhere. Any carelessness should be quickly and always checked as it shows that the muscles have not yet acquired the habit of instant, instinctive obedience—that they are not disciplined.

Any carelessness allowed on the parade ground will bear its ugly fruit on the battlefield where we require that under whatsoever stress of circumstances, danger and death, when the soldier hears the word of command his muscles if not his mind shall instinctively obey it.

So long as we continue to teach the soldier individualism and independence, so long will fire discipline be difficult to the verge of impossibility, but since we *must* teach independence and initiative in the soldier we should jealously seize every proper opportunity to impress upon him the necessity for instinctive obedience and insist upon an absolute and smart compliance with the text of the close order drill book.

Practically all of the civilized nations have now agreed upon the limiting range at which individual instruction at rectangular targets is profitable and this range (400 meters) has been determined from a

study of the relative dimensions of the error due to the gun, ammunition, atmosphere etc., and those due to the firer alone. Up to 400 meters errors of any considerable magnitude are due to the firer alone and may be pointed out; beyond that range, a slight difference in the powder charge, a gust of wind or any one of a dozen other influences may cause an error whose dimensions while instructive in the theoretical study of rifle fire can have absolutely no bearing on individual fire in battle. Instruction is, indeed, imparted abroad in firing at long ranges—the French practice volley firing at 3000 meters—but only in mass firing, for having taught the soldier the elements of shooting, the most important thing in preparation for battle is that he should be taught to do his part in producing a cone of fire which shall be under the direction of a single will, that at ranges beyond which individual fire at an individual target is unprofitable (400 yds.), he should withhold his fire unless he can combine it with the fire of others in a properly directed and controlled group.

The training of the individual soldier in firing against targets of greater ranges than 1000 yards is not approved by any army, though, as with us, special men who have shown particular aptitude are allowed to fire individually on the range at distances exceeding those to which the instruction of the mass of the men is confined (800 meters—875 yards—in Germany, for example).

Since individual fire in war at such ranges would manifestly be unprofitable, it is evident that the chief purpose and value of such long range firing lies in the fitting of the expert shot for duty as group leaders who will have to control and direct the fire of others, and from his experience make the necessary allowances for atmospheric and other disturbing factors in an estimated range. The limits of profitable

individual fire are arbitrarily fixed by our drill and firing regulations at—

400 yards at man a lying down
500 yards at a man kneeling
600 yards at a man standing
700 yards at a horseman
800 yards at a squad, or line of skirmishers.

It is instructive to inquire into the probability of hitting such targets at such ranges.

Target	Range	Size of Target, sq. inches	Rectangle in inches	Dispersion
Lying	400	250	26×22″	31.4″
Kneeling	500	530	26×42″	..
Standing	600	740	24×68″	44.6″
Horseman	700	1750	50×96″	....

Men are taught to aim at the lower edge of the target, hence, if elevation and point of aim are correctly taken the center of impact will lie at the bottom edge of the target, and, in the case of the lying figure at 400 yards, the percentage of hits, calculated as previously explained, would be only 5.85 per cent, while in the case of the standing figure at 600 yards, about the same percentage (6.2 per cent) would be expected.

That is, in the case of the prone target, the individual shot may expect to fire sixteen shots before striking the target with his seventeenth shot, and similarly in the case of the standing figure, the seventeenth shot is the first we may expect to hit the figure.

A squad firing 8 shots per round would hit either target on the second round, or at the usual rate of fire in say 24 seconds while the individual would require 3 minutes and 24 seconds to make one hit. Of course, in the above calculations it is assumed that

the range is known exactly, and that the figure remains steadfast for the requisite time—a violent assumption in the case of the individual firing for over three minutes.

It is difficult to see any real advantage in permitting an individual to fire at these ranges and targets unless he is a specially trained shot with a relatively small dispersion and good judgment.

The most usual, if not the only occasion for the use of such individual fire would be as sentries or as patrols, but when one fires at all it should be with a greater expectation of hitting than exists at the generally accepted ranges and targets considered above. The problem is not unlike that which confronts the hunter of large game with a rifle. He would be indeed confident who, after following a moose all day would venture a shot at last at a range of 700 yards!

Generally speaking no individual shot should be fired, the range of which exceeds the limit of point blank danger space, or which requires an elevation greater than the "battle sight" (530 yards).

Lack of space prevents a review of the target systems whereby it is sought to fit the soldier for firing in war, but generally they teach individual fire up to 400 yards on the range, individual and collective battle fire at longer ranges and at battle targets, lay special stress upon estimating distance, rapid loading and firing and at the mid and long ranges teach an absolute subordination of individual ideas to the will of the commander. The student would be well repaid for the study of the best foreign systems—especially those of Germany, Italy, Switzerland, and Norway.

In any game, such as base ball, foot ball, and the like, it is a recognized principle that individual ideas, however brilliant, must be repressed that the will of one man may be given full and loyal support;

such is foot ball or base ball discipline and a similar cöoperation and discipline must obtain within the fire unit. The soldier, so long as a leader remains whom he can hear, must set his sights as directed, commence and cease firing when ordered, fire only the amount ordered and that at the designated objective; and only when all the leaders are gone and no other soldier has assumed command can he exercise any discretion in these matters. All of this does not mean that it is desirable to convert thinking men into machines, but rather that so long as their mental activity remains they should intelligently cöoperate with their fellows in an effort to produce a cone of fire which the director can use to the best advantage, and that when the reasoning powers are dulled, and the ear deaf to conscious impressions he will still produce an effective cone through instinctive obedience.

Intelligent cöoperation presupposes a knowledge by all of the part each is to play, a loyal subjection of self to the common good when necessary and an ability properly to perform any assigned or casual duty in conformity with the general plan.

The soldier must be impressed with the idea that individual fire at ranges greater than 400 yards is generally to be condemned; and he must understand the general theory of the cone of fire which the officer turns as a jet from a fire hose, first on one target and then on another, and that his part of the cone can only be properly placed when he adjusts his sights exactly as ordered and aims as carefully as may be at the designated objective. Any attempt on the part of the individual to improve upon the judgment of the director in either particular will result in depriving the cone of one rifle and nullify to that extent the efforts of the director.

He must understand what is meant by the *direc-*

tion, control and execution of fire. That the captain alone *directs* the fire so long as he is in command, that upon his death, disability or withdrawal the 1st Lieutenant will direct the fire and so on through the probable hiarchy of command. That in directing the fire the captain will indicate to platoon commanders when to open fire, what elevation and windage to use, what target to aim at, what kind of fire to be delivered, its duration, etc. That the lieutenants, sergeants and corporals *control* the fire, in doing which the lieutenants will repeat in an amplified form the orders of the captain and then that all the fire control officers will see that the elevation and windage ordered is used by the firers, that careful aim is taken at the designated objective, that there is no wild or uncontrolled fire, no skulking, lagging, or carrying off wounded to the rear; but that everybody *instantly* leaves his cover and advances at the command. They will reorganize the units that become mixed, appoint new leaders and generally *control* the firing line.

This control of the firing line is no half-hearted matter, but one of iron firmness enforced, if need be, by the leader's weapon, for the slightest defection upon the part of a single man spreads like wild fire and all order and discipline is at an end. This should be especially impressed upon the soldier, and that he, himself, must assist—by force, if need be—to enforce fire discipline and to require any cowards to advance with the line.

In our present form of tactical deployment, a confused mass of men from many companies and battalions will be crowded into covered spots along the front of the attack, new squads, sections and companies will be formed only to dissolve again a few hundred yards further to the front, and these new units will, many of them, be without leaders. It is here that individual training and initiative will be in-

valuable, and the more his fighting intelligence is de-developed by instruction and drill in this "mixed" phase of the attack, the better will the soldier acquit himself at this time.

The flatness of the modern trajectory has increased the cover-value of even slight folds in the ground and the soldier must be made to understand this and to turn to account every accident of the ground great or small which will increase the effect of his own fire and minimize that of the enemy, but instruction in the use of cover should be carried out intelligently, for the individual of a line cannot blanket the fire of his comrades in an effort to find protection for himself in a depression to one side of or in front of his proper place, and this instruction should go on hand in hand with the moral training that will insure endurance of the enemy's fire, even when it can not be replied to, and that will enable the advance to continue even when the losses are heavy so as to open an effective fire at a shorter range, Indeed, this moral training, the instilation of the pugilistic quality of "Grit" that will stand punishment in order to give it, is of greater importance than training in seeking cover, for the greatest source of losses in battle is not the killed and wounded, but the skulkers who are hugging the ground in every conceivable sheltered spot.

Fire Control, consists in transmitting to the men the instructions of the director in the form of orders and in seeing that these orders are implicitely obeyed, and the controllers of fire are further charged with the police of the battlefield insofar as their own unit is concerned.

The necessity of a thorough understanding of the subject is quite as important here as it is among those lower in rank and the non-commissioned officer especially must be made fully to grasp the extent of his

duties in this connection. He must know the theory of fire tactics, be practiced in both direction and control, trained to change instantly from one set of duties to another and higher set and above all be impressed with the fact that his usefullness on the battle field will largely be determined by the influence which his position, experience and matured character insures over the skirmishers in his vicinity.

The non-commissioned officers are the mainstay of the officers in maintaining fire discipline, they should be the first to follow the officer, drawing the men forward by their example and should be ready instantly to take up the officer's duty should necessity therefor arise.

In order that the non-commissioned officer and squad leader may properly perform his many and important duties, he should not attempt to take part in the firing except in case of emergency, for it will be impossible for him to attend to his main duty of control. Himself firing, he cannot watch the expenditure of ammunition, see that the proper direction and elevation is maintained, check wild firing, pass on orders to neighboring groups, nor cause the firing to cease promptly by repeating the whistle of the commander.

The subject of fire direction has already been discussed in several of its phases, but the importance of the subject warrants a review of the duties of the fire director.

The director receives from the next higher commander information as to the direction in which the advance is to be made, or as to the position which is to be captured, as the case may be, and sometimes the special portion of the hostile line at which his fire is to be directed. He is also informed of the general object in view and the special part, if any, that his company is to play in accomplishing this object.

Special instructions may also be given as to the details of ammunition supply, time or place of opening fire by the battalion, etc.

With these general instructions the company enters upon the advance, and from henceforth the details of his action are within his discretion, so long as he carries out the general task imposed upon his company.

In performing his duties he will—

1. Allot to each platoon a certain portion of the enemy's position at which to fire, so as to distribute the fire of the company over the whole target.
2. Ascertain the ranges.
3. Decide when to open fire.
4. Control the tactical movements of his company.
5. Watch the movements of the enemy.
6. Watch the effect of his company's fire.
7. See that the ammunition sent forward by the battalion commander is properly distributed.

Distribution of Fire.—In the preceding chapter the effect of fire was discussed in terms of the percentage or number of hits. Such a measure of fire effect serves very well for the technical discussion of fire but one cannot measure tactical results in this way.

A large number of hits may be so concentrated on the target that while the percentage of hits is large, the number of figures hit, and consequently the battle efficiency of the fire is small, for it is the number of men disabled that measures results in war.

Now if the fire is equally distributed over the whole target the greatest possible number of figures will be hit (the *percentage* of hits to shots fired remains, of course, the same), but even if the fire is equally distributed many targets will be hit more than once unless the number of hits is very small in

proportion to the number of vulnerable figures. That is, in an equally distributed fire, the number of disabled figures depends upon the ratio of the number of hits to the number of figures contained in the target.

General Von Rohne in his "*Schieslehre fur Infantrie*" has elaborated a table which facilitates the estimation of the probable number of stricken figures under the varying conditions of number of hits and number of targets. Without reviewing the mathematical demonstrations upon which the table was constructed, it will be sufficient to say that it presumes an equal distribution of fire over the whole object and that all the figures present equal vulnerable areas. These conditions will never, of course, be met in service firing, for infantry fire will not be as equally distributed as the theoretical "equal distribution" nor even as equally distributed as is artillery fire, nor will all the targets be equally exposed and so equally vulnerable. The effect of this will be to lessen the number of figures hit as determined from the table, nevertheless the table affords an instructive guide to the estimation of fire effect.

A single illustration will suffice to show the influence on the fire effect of a varying density of the skirmishers forming the target, and consequently the number of cartridges that will be required to produce a desired result in figures hit.

Let us suppose that 600 cartridges have been fired at 80 targets one yard apart and with an accuracy that promises 8.62 per cent of hits, calculated as explained in the preceding chapter.

The number of hits will be 600×8.62 per cent = 52, but with a highly concentrated fire all of these 52 hits may be in one figure, in which case the number of men disabled would be one, and the percentage of stricken figures 1.25 per cent. Now, if

the fire is equally distributed the average number of hits on each of the 80 targets would be $\frac{52}{80}=0.65$. To convert this result into the probable number of figures hit but once would require a lengthy, if simple, computation, which General Rhone's table seeks to avoid, and reference to the table shows that where the average hits per target is 0.65, 48 per cent of all the targets would receive one hit each; or in the case of 80 targets, 38 or 39 figures would be hit. The gain in this case due to the distribution of fire is evident, and a similar gain would be observed in all other cases.

But let us suppose the 80 targets placed two yards apart, then the percentage of hits would be reduced one half because of the reduced proportion of vulnerable surface and reducing the percentage of hits $\frac{1}{2}$ reduces the number of hits in a similar proportion and consequently the number of figures hit with 600 cartridges under these conditions would be but half of that previously ascertained, or 19 or 20 men out of 80, as before, therefore with a given number of cartridges fired, the percentage of figures hit depends upon the front occupied by the target.

Again, let us suppose that with this same extension (2 yards interval) the fire is concentrated on only half of the target (80 yards of front). Now the percentage of stricken figures will remain as in the first case considered (48 per cent), for with 26 hits on 40 targets the average number of hits per target would be $\frac{26}{40}=0.65$, and the percentage of stricken figures from the table would be 48 per cent as before, while 19 or 20 figures would be hit in a front of 80 yards. Hence, with a given front of target, the percentage of stricken figures depends upon the expenditure of ammunition.

With this knowledge we can calculate the prob- number of cartridges that will be necessary to dis-

able a given percentage of the hostile skirmishers, for if n men fire against a front n yards wide every man must make as many hits as will be required to disable a given percentage of figures.

From General Rhone's table it is seen that to disable 50 per cent of the hostile line, it will be necessary that each figure receive on the average 0.69 hits. As previously explained we can calculate the probable percentage of hits in any given target with any assumed dispersion, and if by such computation it has been determined that 14.8 per cent of hits may be expected, that is, that 14.8 hits will result from every 100 rounds fired, then with an equally distributed fire against a target n yards wide from which we need only an average of 0.69 hits on each fiigure, it is evident that n men need only fire $\frac{0.69 \times 100}{14.8}$, or 4.9 cartiges each.

If double the number of men are firing (2n men against n yards of front), then only $\frac{1}{2}$ the number of rounds need be fired by each man; but if, on the other hand, the target is twice as wide (n men firing against 2n yards of front) then twice the number of cartridges will have to be fired by each man.

From the foregoing one must not assume that such calculations are precise nor that they are to be made on the battle field. The object sought is to so familiarize ones self with the subject as to enable one to form a reasonable estimate on the battle ground of the number of cartridges and the length of time necessary, under certain conditions, to produce certain results. A careful study of General Rhone's work will well repay the student.

The distribution of fire along the whole front of the target is accomplished by alloting certain and definite sectors of the hostile line to each platoon and conveying this information to each of the sections

and squad leaders so that all in authority may know exactly upon what part of the target their fire is to be directed. It presupposes the selection of the target, and this selection must be base upon the relative *tactical* importance of the several potential targets.

Generally the most immediately threatening target is chosen, or that which is about to become the most threatening, but fire is often profitably directed on targets which because of their width, depth, height or dense formation are likely to render the fire especially effective.

Advanced troops will have their target designated by higher authority but the fire director will divide the hostile front into sectors, alloting firers for each. When any group has subdued its sector it will reserve its fire or combining with other groups, concentrate it on another part of the target, returning instantly and without orders to its alloted sector at the first sign of renewed activity therein.

DETERMINATION OF THE RANGE

There are five recognized methods of determining distance:

1. By pacing, (man or horse) and by timing a trotting horse.
2. By ocular estimation.
3. By trial firing of artillery or infantry.
4. By measurements on large scale maps.
5. By various optical instruments.

Pacing is inaccurate, is useful only for short ranges and not in the presence of the enemy, and the same may be said of measurements made by timing or pacing a horse.

Estimating distances by eye.—This is the most practicable and usually the only available method, but is subject to very large errors as has been pointed out. By far the most reliable results when using this method are obtained by averaging the es-

timates of several trained men, and it is usual in foreign armies to designate several such men to accompany the fire director, so as to reduce to the minimum the loss of effectiveness in fire due to incorrectly estimated ranges. It is idle to commit to memory and expect to rely upon the details of dress that are "visible" at a stated number of yards, since the enemy is usually prone or at least partially hidden. Practice in peace under simulated war conditions will increase the individual accuracy but will never wholly eliminate the errors which are inherent in this method of determining distances.

Trial firing.—This is practicable for infantry only when the ground in front of the target is suitable for observing the fall of bullets and is visible, when the target itself is stationary, when no other troops are firing on the target, when the firers are not, themselves, under a heavy fire and when time is available. When employing this method, volleys are fired by section, care being taken to have all rear sights accurately set and to have the volley as nearly simultaneous as possible. The director should place himself at a little distance from the firers, rivet his attention on the target and "bracket" the target, firing the first volley at the estimated range; if the strike is short increase the elevation by 100 or 200 yards and fire another volley, and continue until a volley is seen to strike in rear of the target. When a volley striking short and one striking over differ by 200 yards in elevation a "Long Bracket" is formed. This distance is halved and two more volleys are fired, if one is still in rear and another in front of the target, halve the difference in elevation and continue until a "short bracket" (of 50 yards) is formed with the target between the two strikes. The better the marksmanship of the firers—*i.e.* the smaller the dispersion, the easier will it be to estimate the point of

fall, hence, where time permits, it is often advisable to make up two sections of picked shots for this ranging fire. One great advantage of this system is that the result is found in terms of back-sight elevation rather than in yards of distance which latter must always be converted into elevation with due regard to atmospheric conditions.

Taking ranges off the map.—This is usually impracticable owing to the small scale of the maps available, nevertheless if a combined sketch has been made of the ground after the methods taught at the Service Schools it will furnish a most valuable aid to rangefiring. In using the map, allowance must be made for firing up or down hill—according to Colonel Rothpletz, an addition of 10 per cent of the range must be made for an angle of site of from 10° to 25°, and 15 per cent for an angle of site of from 25° to 45° whether the target be above or below the firer. This allowance serves only to find the true distance between the two objects (maps, it will be remembered, are made by reducing all sloping distances to a plane surface and hence a map distance is not a true distance except on a level plain), a still further allowance must, of course be made in reducing range to elevation for an inclined line of sight.

Rangefinders.—The "Weldon", the "Pentaprism" and all range finders of like limitations are practically useless for battle purposes, both because of the difficulties attending their use and because of their inherent inaccuracies, especially when the base is paced, or the instrument is used by unskilled men. Unless the base is accurately measured and the instrument used by men who have been trained to its use, estimation of the distance by eye will be far more accurate than a distance determined by the rangefinder. The *Above* rangefinder recently adopted by our artillery is at once the most accurate,

simple and useful instrument ever invented for this purpose, but even *its* use by infantry would be limited to defensive positions or to long range firing when time is not an important factor. The range-finder must always be considered an adjunct to, not a substitute for visual estimates.

Having determined the distance (range) the director will have to make the allowances which his training and observation indicate so as to give to the troops the *elevation* which they are to use, for a knowledge of the actual range is but a preliminary step toward the designation of the proper back sight elevation and it is this—the *elevation* which must always be given to the men, and never the *range*.

Long Range Fire:—At the very outset of an attack the fire commander is confronted with the question as to the advisability of using long range fire. The anwser to this quesion is axiomatically stated by Colonel Lamiraux in his "Principles of Fire", that "We should fire whenever the effect produced, or to be produced, whether it be physcial or moral, is in proportion to the consumption of ammunition". The statement will readily be accepted by all, but its application to a concrete case may not be apparent. The effect to be anticipated depends upon the distance, the size of the target and many minor factors and can be theoretically computed as shown, and the theoretical deductions may be proved by experimental firing.

With long range firing very small physical results will always be the rule unless the mistakes of the enemy lead him to present a favorable target. The great range possible to the modern rifle will make these chance targets much more frequent than at first might be supposed. Here a battery with its mass of men, horses and wagons will expose itself going into or changing position and at the range of

2000 or even 2500 yards it will with difficulty keep covered throughout its march. When one thinks of the confusion and loss of time and morale that will result from the killing of even one or two horses, that must be cut out of the harness before the march can continue, is it profitable to consider that at the range assumed, only two per cent or even one per cent of hits will probably result? Here, the moral rather than the physical effect may be "in proportion to the consumption of ammunition."

In these exceptional cases, it must be remembered that the troops firing are still calm and their discipline as yet unshaken, so that the dispersion of their fire will be but little greater than the same troops produce in field firing experiments. In such firing at our School of Musketry, against a target 11 yards front and 40 yards deep, with the range determined by the Weldon Range Finder (5.7 per cent error), "good" marksmen attained at—

1800 yards, 58 per cent
2000 yards, 54 per cent
2200 yards, 42 per cent of hits

That is, with 31 men firing for one minute there were—

54 hits at 1800 yards
50 hits at 2000 yards
39 hits at 2200 yards

The use of long rang fire to obtain fire superiority is quite another thing from these chance targets. It is safe to say that there will be no more "Plevnas" where massed supports to a thin skirmish line will wither away under a long range fire, and the Prussian Guard Corps will never repeat the formations which at St. Privat cost them 6,000 men (one-third their number) in thirty minutes; rather will the defender see only targets which will assure him small physical returns for his fire, and the at-

tacker will see, at best, but a line of turned earth, very indistinct and very distant, when he hears the whistle of the first bullets. The necessity of reducing the number of cartridges to be fired by the advancing line, together with certain obvious considerations concerning the morale of the troops, dictates that the line should advance without firing until the losses become too great to be disregarded and the men will not advance further without firing.

The point at which firing is to commence is, therefore, usually dependent upon the efficacy of the hostile fire. Theoretical determination of the range at which fire shall first be opened is perfectly idle. He who reserves his fire until the men begin to fire without orders invites disaster through the impossibility of then establishing fire discipline and through a loss of morale at this stage which no expenditure of cartridges can subsequently revive; on the other hand, almost as dire results will follow the premature opening of fire. The director of fire must keep his fingers on the pulse of his fire units, and, at the psychological moment, beyond which his men will not advance without firing, he must order fire of such character and intensity as the conditions demand, keeping always in mind that his only assurance of success lies in reaching a point at a suitable distance from the enemy from which a superiority of fire can be established over that of the defender and in having enough rifles at that point to effect that purpose. The closer this point is to the hostile position the better, but its actual distance will depend upon the intensity of the enemy's fire, the character of the ground, the training of the troops, and perhaps—as in the case of the Prussians in '70-'71—it will depend upon the relative excellence of the arms of the opposing troops. It may be anywhere between 600 and 1,200 yards from the enemy. It should con-

stantly be kept in mind that when we commence firing we wish to produce some decisive result—not merely to inconvenience, but to destroy the enemy, and this we can never do with long range fire.

Having reached the point where the fire is to be opened, the struggle for supremacy begins. The number of guns that the artillery can turn on the hostile line at this time will be a not inconsiderable factor in the director's problem of the infantry fire, and, that he may work it out successfully, he should be familiar with the probable effect of artillery fire as well as that of his own. Too much reliance upon the artillery will lead to a premature starting forward of the line and the struggle for fire superiority will be carried on from halt to halt, whereas supremacy should be firmly established at the longer ranges and merely maintained at the subsequent halts. On the other hand, an undervaluation of the probable effect of artillery fire will lead to much long range infantry firing, waste of cartridges, and a premature opening of fire with all its attendant evils. It is too often the case that the infantryman, believing the subject of artillery fire outside his work, draws from current reading an idea that artillery fire is either all-powerful and annihilating or that it is impotent, according to the author or casual instance read. Of course neither of these is true; the subject is fully covered in a score of text books and the infantrman is urged to take up the subject of artillery fire as being one so intimately connected with his own work as to be really a part of it.

In the ultimate, the fire of infantry and of artillery will be found to be so similar as to be practically identical at animate targets, the radius of potential efficacy being the chief difference, so that if we assume that the infantry are able to reach a point where their fire becomes truly effective, the combined

artillery and infantry fire will be exactly like artillery fire from a very great many batteries, or like the fire of a much greater number of rifles than really are in use—the artilleryman conceives it one way, the infantryman another and both are correct. Hence it is, that if the artillery of the attacker is deficient either from lack of guns or from the activity of the hostile artillery, so that the infantry line cannot reach the advanced point from which it hopes to gain superiority, the deficiency may be remedied by occupying a flank or elevated position somewhat similar to an artillery position but more advanced, with a body of infantry from the reserve troops which hastily entrenched, firing from rests, with no prospect of a near approach of the hostile line can so augment the fire of the artillery directed on the hostile infantry as to bring its fire up to the required standard of efficiency and permit the advance of the attacking troops to an effective range. The fire of such advanced troops is generally very effective, because of their calmness, the unchanging range, their non-participation in the assault proper and the facility with which they are supplied with ammunition. A regiment so employed, firing at 1000 yards can produce as many hits per minute as will 12 batteries firing at 3000 yards at the same target, but it can only do this when its fire is as scientifically directed and controlled as is that of the batteries. Long range fire is therefore limited to these two occasions —chance targets and special troops; the artillery and if necessary special, advanced, troops should permit the firing line to advance until it reaches a range where it's fire is certainly effective and when it reaches this point it should do so in such numbers and in such formation that the fire will assuredly beat down any fire which the defenders can bring against it. This range will usually be so great as to produce

very large dispersions and to produce, with these dispersions a really complete fire victory it will be necessary either to increase the rapidity of the fire or its duration. Increase of rapidity always means increased dispersions and decreased hits per cartridge and, at this range, decreased hits per minute, It also wearies the men, lowers their morale, tempts demoralization and is generally objectionable. The only other alternative is found in an increased duration of the fire. In either case a greater number of cartridges will usually be fired per man at this halt than at any other—unless it be at the halt just preceding the assault.

In the succeeding halts, if the proper effect was produced in the beginning it will require fewer and fewer cartridges per man to keep down the fire of the enemy. If on the other hand the fire at the first halt was used merely to allow the men to "shoot up their courage" and if the advance is begun before fire superiority has been definitely attained, it will require a constantly increasing number of cartridges at each successive halt to permit of another advance, and the closer the line is to the enemy, the harder will be the replenishing of the exhausted ammunition, the greater will be the losses and the more difficult will it be to attain fire superiority.

It has been stated that victory is impossible without fire superiority, but it should also be observed that fire superiority *per se* will not assure victory. One cannot shoot a defender out of his position—it requires the steady and irresistable advance, and the threatened if not actual shock with the bayonet to dislodge a stubborn and intrenched enemy.

Fire inferiority is met, whenever possible, by bringing up reinforcements, thus increasing the number ef rifles in the line and tending to throw the balance in favor of the losing troops.. But when the

last available man has been put in the line or when the hostile fire is so comprehensive and so well directed as to render such reinforcement impossible, then the hope of obtaining superiority is so remote that defeat is already an assured if not an accomplished fact. But where reinforcement of the inferior fire is effected, and in sufficient volume, then the obtained superiority may easily be lost unless that line holding it is at once and suitably reinforced. Hence it is that the successful tactician must have such a knowledge of the subject of rifle fire as to enable him to form a rapid and accurate estimate of the fire situation at any moment and so to foresee the necessity for reinforcement before he shall have lost the fire superiority he has gained.

If the defender can prevent the attacker from reaching the short ranges, the success of the defense is, of course, assured; on the other hand, once the attacker has established himself at the short ranges, the defense has little chance of making a successful counter-stroke—for the closer the defender is pressed the more rooted does he become to the ground he occupies.

Long and medium range fire by the attacker must, therefore, always be regarded as only a means to an end, to be avoided as long as possible, a temporary makeshift to enable him to reach decisive ranges and to cover the advance of formed bodies behind the firing line.

Experience has shown that an attacker who opens fire at "long" ranges seldom gets as far as the short ranges, and it is not until short ranges (say 800 yards and under) are reached that the infantry fire action proper commences. The attacking line should aim to reach these ranges strong enough to prevent the defender establishing a fire superiority. Up to this period, formed reserves taking every advantage

of cover have followed the line, those on the flanks at less distance than those in the rear to meet unexpected flank attacks, but when the struggle for supremacy begins the attacker will have to give up to some extent, his distribution in depth.

Effective fire is an essential condition to victory, and is attained, firstly, by bringing more rifles into the firing line than the enemy, and secondly, by better shooting and fire discipline and by taking every advantage of cover. Superiority of fire must be attained before there can be any question of the attack succeeding; any failure to appreciate this principle will lead to such losses that even if the attacker were to succeed in closing with the enemy he would be too weak to gain the victory. Supports and reserves must be close at hand to prevent the defender gaining the upper hand, and to fill up gaps in the firing line. Should the fire slacken, the firing line will endeavor, here and there, to close with the enemy, the neighboring portions of the line joining in and following up such local advances. In the course of this fluctuating fire action the attacker will have succeeded in working up closer to the enemy's position, and will begin to feel that he is establishing a fire superiority. The fire of the defender from that portion of the position which is to be assaulted begins to slacken; here and there a few men, then more, finally whole units, begin to crumble away. Generally, this process must have set in before the assault can take place, or the result will be disasterous. In most cases such will be the effect of an overwhelming fire concentrated at short ranges on the decisive point or points that the final charge with the bayonet will be made on a position either already evacuated or but feebly held.

Here again mistakes have to be guarded against. It is far from easy to hit off the right moment for

making the assault and bringing up solid masses of infantry. The mere fact of the defender's fire ceasing does not prove that his firing line is crippled. (Balck).

An illustrative example of the fruitlessness of an assault without first subduing the enemy's fire is reported by a German officer who served with the Boers, and who says of an attack made by a battalion of English on a small force of untrained German volunteers—"The right wing of the Boers had retreated without any provocation during the night of the first day of the battle, and the English accordingly encircled the right flank of the Boers who were on the top of Thaba Mountain. To the German detachment was assigned the defense of the smaller hilltops in order to attempt to throw back the flank movement of the English infantry. On the hill where I stood there were only thirty rifles. The riflemen were lying at from 3 to 5 pace intervals behind piles of stones, and under the heavy shrapnel fire of the English could scarcely lift their heads above their protection. Under the protection of the artillery fire, the English infantry approached to within 200 or 300 yards and from concealment in the brush; delivered a continual rapid fire, which happily passed over our heads. This lasted for hours and, caused only a few dead and wounded. Then the English artillery was compelled to change its position and their fire on our positions ceased. Several times the enemy started to attack, but were always forced to lie down after a few moments of our fire. Finally the whole English line started—300 to 400 men. As they advanced they appeared like a thick gray yellowish swarm nearly shoulder to shoulder, and in some places three or four deep (as it often happens in peace tactics). Now we opened fire in earnest. At first wild, but very soon, under the cautioning of some experienced riflemen among us,

it became true. Thicker and thicker fell th emen on the advancing side and when the attack had carried up to eighty paces it was stopped, ruined. Some of them threw themselves down between the boulders and fired, but the greater number ran back to the protecting bushes and some of them could not be stopped there. The entire English battalion, for we afterwards found it was such, was destroyed for that day as a fighting body.''

On the other hand is the case reported by Sir Ian Hamilton at the Sha Ho where a brigade obtained fire superiority at about 900 yards and advanced successfully from that position to the trenches at a double time, capturing them after a bayonet attack with those of the defenders who had not evacuated the position.

Under modern conditions of equality in armament, it will be observed that troops have always been successful, or the reverse, in proportion to the instinctive skill of the commander in gaging the effect of fire on the morale of the troops on both sides, in reserving the fire to the last minute and in launching the assault at the psychological moment when the attacker's fire has so lessened the accuracy of the hostile fire that it is no longer able to inflict stopping losses on the assaulting troops. This may happen when the assaulting line is still 800 or 900 yards from the trenches, and again it may not happen until the distance between the lines has been reduced to 50 yards—both limits were reached during the recent war in Manchuria.

The old ''Chief Fire Position'' at 200 yards (Inf. D. R. 237) has completely disappeared and instead of a gradually increasing intensity of fire during the attack will be a gradually *diminishing* intensity if the necessary fire superiority is gained, as it should be at the outset.

Having gained the superiority at the long ranges, it will require less and less fire to maintain the preponderance, because the shorter the range the less the dispersion, and so the greater the percentage of hits by the troops having the balance of effect in their favor, while the subordinated fire will, because of decreased morale and wider dispersions, grow less and less effective as the distance decreases. This decrease in the efficacy of the defender's fire will permit reinforcements to be brought up by the attacker in better order and with less loss, fewer will be needed in the firing line, the duration of the fight will be shortned, and more troops will be in hand to reap the reward of the attack in the pursuit at which time the magnitude of the decision is determined. The whole course of the war often depends upon the magnitude of a single success as is illustrated by the Battle of Jena, where a decisive Prussian success would, undoubtedly, have resulted in a union of the Russian, Prussian and South German states, a crushing of the French, and a saving of nine years of war and two million lives—surely a result worth striving for—and a recompense for the time spent by the officers and men in preparing in peace for their work in war.

The decisive fire is, therefore, the mid-range fire—according to General Kuropatkin from 1200 to 600 yards,—for at ranges greater than 1500 to 1800 yards, and again at ranges below 400 yards the dispersions will be so great that the resulting hits will rapidly diminish, in the former case because of material influences and in the latter because of moral influences. When the assailant has arrived at a short range, the morale of the defenders is shaken, the emotions of the fight are at their greatest intensity, and any want of skill influences both the rapidity and especially the accuracy of the fire which, therefore, becomes less effective. On the side of the attacker, the

dispersions due to excitement and increased danger are still further increased by the fatigue and prolonged strain of the attack. The fire of both lines at 400 yards or less becomes so erratic as to be quite as undecisive (physically) as it was at 2500 or 2000 yards. This has been observed in all wars since the introduction of the breech loading rifle. Of the Franco-Prussian War, General Paris (Prussian) says "Once the long range zone had been crossed, the men were little exposed, because the bullets passed too high". In the Russo-Turkish War the reserves frequently rushed into the firing line to avoid the losses to which they were subjected at long range. Speaking of the Russo-Japanese War, a writer who served throughout that war comments upon the great falling off in the effect of rifle fire at short range, and says "No harm at all was done at 150 meters or less owing to 'Nerves' ".

The object of an attack is always to paralize the defender; that is, to give him such a number of dead and wounded that his resistance may be broken before that of the attackers. On the side of the attacking force every rifleman has to deliver an effective fire and this against only a head high and generally intrenched skirmish line. The attack (and surely the attack is the whole training of infantry) has first to be able to recognize such targets; second to be able to fire at such targets effectively—neither an easy task.

Concerning the art of picking out targets of this kind, the Austrian Regulations say. "On the drill field one should not only choose the targets which are easy to find, which are visible at short ranges, but gradually should pick out those at longer ranges, smaller targets, harder to discern both from the terrain and to pick up. If possible, the training should be against living targets. In this way officers may

learn to designate such targets clearly to the men and the men will get accustomed to recognizing them and picking them up quickly. The art of recognizing such targets is often very difficult and frequently possible only with good field glasses. Officers and noncommissioned officers must be drilled in the art of finding such targets, and must learn to designate targets which are not clearly defined so that their designation may be clear and distinct to their men, and thus allow every man to pick up the target and deliver an accurate fire upon the desired spot."

A single trial will convince any officer of the wisdom of such training and will show the difficulty of picking up a target against an earth wall, on the edge of a wood or field even at short ranges and how almost impossible it is at first to distinguish any target at all at from 800 to 1200 yards. The difficulty increases with the invisibility of the color of target, hence foreign targets are usually of olive drab, gray, khaki or some probable field color, and at our own school at Monterey, the field firing is now done almost entirely against olive drab targets.

Thus far we have discussed fire in general without inquiring into the character of the fire to be employed, whether it shall be individual or collective,—"independent"—a word strangely out of place in the military vocabulary, or "controlled". Let us now investigate this phase of the question.

The ideal fire in battle is that fire which is immediately and completely responsive to the will of the commander. Given a fire, however powerful, that is erratic and independent, representing thousands of individual wills and impulses rather than a fire that is the expression of a single commanding will, and the efficacy of the former will be so materially less than the latter that superiority of fire will be attained,

if at all, only at a tremendous cost in ammunition, time and lives; coöperation, the keynote of success, will be incomplete or impossible, and the scientific direction and use of fire a mockery.

That fire in battle should always be controlled fire up to the period when control becomes no longer possible and that every effort should be made to postpone the beginning of the uncontrolled fire is so obvious as scarcely to need comment, but the best method of controlling the fire is not so apparent. Various methods of controlled mass firing have resulted from attempts to solve this problem, the oldest and most prominent of which is to cause the fire to be delivered by all the rifles of a fire unit at one time and at one command—the volley. However useful and appropriate the volley was at its inception in the days of dense formations, short ranges, slow loading, inaccurate fire, etc., it can no longer be regarded as possible or even desirable except in two very unusual conditions, both of which occur at long ranges. These two conditions are—

1st. For ranging purposes, and

2d. For massed and favorable targets.

For all other phases of the fight, the true volley is impossible and any discussion as to its relative value must be purely academic. At long ranges, where the influences of incorrect estimation of the distance is most potent, the volley may prove useful in determining the range. The use of the volley for this purpose demands that no other troops fire at the target during the progress of the ranging fire, that the ground be reasonably favorable for observing the strike of the bullets and that the director be so well versed in the art of observing fire as to permit of his drawing probable deductions from the strike observed. With these conditions present, ranging fire is conducted as previously explained. Volleys may also be

used when the troops are still in closed formations and a favorable target is presented, as already explained, whether the firing be done by the troops of the attacking force or by reserves. Such fire also will be used by advanced troops who are engaged in assisting the artillery and in much the same way that the artillery is using its "zone" fire.

With the development of the rifle and the use of skirmishers, the "Fire at will" came as a natural consequence of the changed conditions. It is, as Colonel Lamiraux says, "The true fire in war." But this individualized controlled fire quickly degenerates into rapid fire, and even into uncontrolled fire, and it is difficult both to direct and to control. It consumes a vast amount of ammunition and must be executed with pauses for the purpose of changing sights, steadying the men and preventing a waste of cartridges. Pauses may be caused by—

1st. Limiting the number of rounds to be fired by each man.

2d. Limiting the time during which fire shall continue.

The former will be used in the earlier stages of the attack and the latter at the mid and short ranges. The fire with counted cartridges in anything less than five rounds is hardly worth attempting. The soldier has so much on his mind and is under such a stress of feeling that he cannot be expected to count two or three shots accurately, but by limiting him to one clip ("clip" or "packet fire") he is automatically reminded when to stop and he will stop, if at all disciplined, at the longer ranges, but as the intensity of the enemy's fire increases and the full excitement of battle seizes the soldier, dulling his reasoning powers, nothing but the officer's whistle should be counted on to stop the fire and to secure the necessary pauses in firing, nor will even this suffice for long, except with

seasoned and well disciplined troops, for the intensity of the firing will gradually increase, the pauses at command grow more and more difficult to obtain and the order "Rapid Fire" will often be but a confirmation of an already existing state of affairs.

Rapid fire in the last stages of the fight is almost wholly moral in its effect, little or no physical results being possible in view of the enormous dispersions due to the angular errors of the firers, and this is true even with the flat trajectory which requires at the short ranges little more than that the rifle be held parallel to the ground.

Rapid fire, ordinarily, should be used only on those rare occasions when either a favorable target is presented, a close encounter with the enemy is imminent or some other necessity demands that no stone be left unturned. Conducted, directed and executed with calmness, such fire will often be found effective, especially when used after the manner of the "Rafale" (fire storm).

The use of the rafale by infantry is a natural outgrowth of its use by the field artillery. It is the invention (as to the artillery) of General Langlois and has for its object the production of an absolutely paralysing, instantaneous effect produced by suddenly delivered, very violent gusts of fire of short duration, separated by more or less prolonged intervals of calm. It has many of the advantages of volley fire, avoids some of its disadvantages, but has disadvantages of its own that are so great that the rafale must always remain an unusual form of infantry fire, however valuable it may be on occasions.

Much has been written and many experiments have been made with a view to establishing guiding rules as to the best position to be assumed by the firers in combat--standing, kneeling or prone. It is

usual to consider each position from three points of view:

1. Relative efficacy of the fire (smallness of dispersions and rate of fire).
2. Facility of forward movement (and fatigue induced by position).
3. Vulnerability.

Without going fully into this subject, it is sufficient to say that the position is determined in any particular case by sometimes very conflicting factors; that the prone position gives smaller dispersions, but slower firing, than either of the other positions and that it offers the least vulnerable surface. It is, therefore, the position usually assumed, both by the attacker and by the defender, although many eminent writers have combatted the almost exclusive extent to which it has been adopted under any and all circumstances. An example of this is found in the Italian Regulations which give the kneeling position as best on account of the facility with which it lends itself to good marksmanship and which give the prone position as the worst. It is evident that such a statement is based on theoretical considerations alone, and those quite incomplete.

The troop leader in determining this question in any given situation must always remember that efficiency of fire, rather than the minimizing of losses, is the determining factor when they conflict.

As to the relative losses which will be sustained in the various positions, their influence on the decision, while never to be ignored, should be entirely subsidiary to the question of fire effect, as has been pointed out. Useless losses cannot be condoned, but he who undertakes an assault must be prepared to suffer *necessary* losses as the price of his victory. He should remember that although during the at-

tack his losses will probably exceed those of the defender, yet upon the turn of the tide he will reap his reward. The defender, fleeing in disorder and unable to return the pursuing fire, will melt away under the accurate and deliberate fire poured into the large and vulnerable target which he presents. In but a fraction of the time that was consumed in the attack the losses so inflicted will equal, and then exceed those which the attacker has suffered, and these sudden losses will still further demoralize the fleeing troops who will abandon to the successful side the fruits of their victory—in guns, in standards, rifles, stores, and in prisoners.

During the progress of an attack the changing distances which separate the combatants will require corresponding changes in the setting of the sights until the short ranges are reached. Here the excitement of the fight, the difficulty of giving audible commands and the increased dispersions happily combine and render the exact setting of the sights neither possible nor necessary.

With the "Battle Sight" (leaf down) the bullet will not rise above the height of a man standing when the line of sight is horizontal and—

The firers are	prone,	for a range	of	589.7	yards
" " "	kneeling	"	"	"	629.4	"
" " "	standing	"	"	"	718.6	"

Since, at the short ranges at least, both lines will be prone, it is seen that so soon as the distance between the lines is reduced to a little under 600 yards (589.7), the whole space between the two lines is within the danger zone, but a prone target, such as we have assumed, will be within the 50 per cent zone only between the ranges 450 and 610 yards, and the center of impact will lie in the center of the target (point of aim) only at 530 yards which corresponds to the elevation of the battle sight.

When the target is at a distance of 288+ yards from the muzzle (at the summit) the center of impact will lie about 2.4 feet above the center of the target, and the efficiency of the fire will be least. Assuming a target 22 inches high and double the dispersion of average marksmen (=unshaken "poor" marksmen) or about 44 inches at this range, we would have—

P.F. = $\frac{82}{44}$ = 1.8 = 79 per cent.
P.F. = $\frac{38}{44}$ = 0.86 = 44 per cent.
79—44 = 35; $\frac{35}{2}$ = 17.5 per cent of hits on a wall target.

With a correctly placed center of impact and the same dispersion we would expect—

P.F. = $\frac{22}{44}$ = 0.5 = 27 per cent of hits.

While if we assume a correct range and "average" dispersions, we would expect—

P. F. = $\frac{22}{22}$ = 1.0 = 50 per cent of hits.

The excitement of the fight would, therefore, probably cut the expected percentage of any given body of men almost one-half and adding the use of the battle sight the results would drop to about one-third of the normal. This loss of effect cannot be avoided, but must be anticipated and provided against by an increase in the rapidity of fire or increase in its duration according to circumstances. It should be evident, from the above, that to halt a line at from 200 to 300 yards from the enemy while using the battle sight is to put a heavy handicap upon it; since at this range it can expect only about half as many hits from a given accuracy of fire as it was making with the battle sight at 500 yards. Poorer shooting at the shorter range will tend to diminish the handicap but only to a small extent as we have seen. The improbability of *attaining* a superiority of fire at ranges less than 500 yards under normal conditions is also made apparent.

There is another use to which the "Battle Sight" is properly put which deserves consideration, i.e., in repulsing a cavalry charge. Here it is a question of using the battle sight, which can hastily be set, or of using correct sights frequently changed, or an arbitrarily chosen sight incorrect except for one range—for instance 600 yards. General Von Rohne in his "*New Studies*" has gone quite extensively into this subject, basing his calculations on the '88 (German) rifle and for cavalry under fire for 800 meters and 500 meters respectively. His conclusions as to the adequacy as well as to the absolute advantage of the battle sight over the others considered (600M, 500M, 450M, Battle Sight and Small Leaf.) are conclusive for his rifle and assumptions and are borne out by historical examples of losses. Similar computations based on our rifle and conditions serve to confirm and to emphasize the advantage of our battle sight, against a rapidly moving target at ranges of 900 yards and lower.

In the foregoing discussion, whenever principles were laid down not applicable to both combatants in common, the use of rifle fire has been discussed from the point of view of the attacker. This has been done for two reasons; first because the mental attitude of the student is usually aggressive and because certainly in war the offensive offers the greatest rewards; second because the fire fight of the attacker presents the more varying problem.

With a knowledge of the methods by which the attacker may hope to gain fire superiority, the problem of the defense becomes one merely of preventing him from attaining that superiority in the manner prescribed. The attainment of fire superiority thus constitutes the real tactical problem. The whole art consists in inflicting in the same time more losses upon the enemy than he himself causes. Now, if the

intervals, vulnerable surface and marksmanship of the two sides be equal but one side be numerically stronger—say as two to one—it is clear that the stronger will inflict upon the weaker double the losses in a unit of time. For example—other things be equal—suppose the strength of the forces to be 100 and 200 men respectively, (proportion 1:2). The stronger will lose 10 while the weaker loses 20 in a unit of time. They will begin the next unit with 80 and 190 rifles respectively (proportion 1:2.375) and the numerical superiority of the stronger will increase with each unit of time considered. The first rule, therefore, is to open fire with the greatest possible number of rifles. This is a rule equally applicable to both sides, but in a concrete case the defender will generally be numerically weaker and to overcome this disadvantage he must avoid everything which will increase his losses, and he must do everything in his power to increase the efficacy of his fire. As we have seen, losses are reduced by extension of front (intervals) and by reducing the vulnerable area of the target, hence the defender will utilize all the space at his command and will intrench or fire from a prone position according to circumstances. He will augment his fire by putting into the firing line as many rifles as can be used without mutual interference so that each rifle may exert its maximum of effect. Where time admits, ranges will be accurately determined in the foreground and thus one of the most potent causes of reduced efficiency will be removed.

Zones are registered and established by noting the distances to physical objects such as prominent white stones, insolated groups of trees, houses and the like, and if possible by drawing on a map range lines at 100 yards intervals on the ground over which the hostile infantry must advance. Here the modern

"combined position sketch" will find its phase of chief usefulness. It should be perfectly evident from what has been said on the subject that that fire which is directed with correct elevations, will be vastly more potent than that directed with guessed elevations, hence that this determination of ranges gives the defender who uses it skillfully a decidedly more efficient fire per rifle than is possible to an attacker.

From a study of such a prepared map and reference to the ground before them, company officers should be able to recognize the moment the hostile line passes the 1000, 900, 800 yards etc. line and to direct against it a very powerful fire.

At the long ranges, difficult accurately to determine and to recognize and where the dispersion in depth of the effective zone is small, necessitating combined sights, the defense can make effective use of what the artillerists call "progressive fire". With the advancing hostile line at an estimated distanceof say 2000 yards, the right company of a battalion fires one volley at 1800 yards, the second company follows immediately at 1900 yards, then the third at 2000 and the fourth at 2100. The right company comes in immediately at its old range of 1800 and the process is repeated until a change of sights is rendered necessary. In this way a zone 300 yards in depth containing the hostile line is established, and while accidental maximum results are renounced, certain if lesser results are obtained. At these long ranges and using progressive fire, the advantage of individual fire in the matter of more perfect aiming is imaginary and the controlled volley will produce the more effective fire.

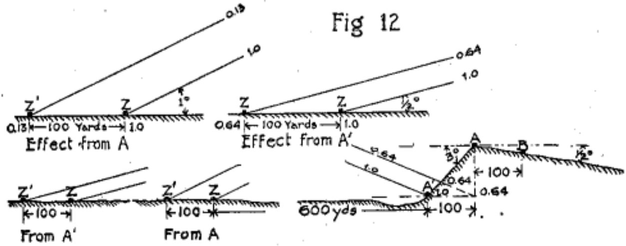
There is an apparent inconsistancy between the desirable wide front and the putting into the line of the maximum number of effective rifles, but the extent of front which can, or should be occupied is nec-

essarily limited by tactical considerations and by the difficulty of directing fire in an unduly extended line. Excluding outpost engagements and the like, the available space is clearly fixed and within these limits the largest possible number of effective rifles must be placed, avoiding crowding to an extent that will hinder men from properly handling their rifles, and never forgetting that each rifle not utilized may cause a dimunition in efficacy and facilitate for the enemy the attainment of fire superiority. Tactical considerations of withholding part of the troops as a reserve are, of course, outside of this discussion, which aims to deal solely with the question of fire effect.

There are certain phases of the effect of slopes which are especially pertinent while considering the defense and which were not brought out in the preceding chapter. The importance of the subject warrants the further inquiry.

In maneuvers, one usually sees the crest line chosen for the position of the firing line, with the support in slight depressions in the belief that the best fire effect is obtained from heights and that depressions give the best protection from the enemy's fire because one connot be seen there. As Von Rhone remarks "There is something of an ostrich's nature in man". Having reference to fig. 12.

Fig 12



In the great majority of cases the point A will

be chosen for the firing line and the point B for the support, while it would be more correct,—at least from the standpoint of ballistics—to push the firing line so far to the front that it would still have an effective fire of from 600 to 700 yards, for instance to A′ and to advance the support to the vicinity of A. The fire from A is plunging, from A′ it is grazing; at B the support at B would suffer from the fire directed at A while this accidental effect would be reduced if not prevented by posting the firing line at A′ and the support near A.

Ignoring the question of the tactical advantages of one position over the other as being outside this inquiry, let us look at it from the point of ballistics solely, grasp the truth of the above statements and investigate their measure of importance. In a concrete case the tactician may then determine his position with a fully formed "Estimate of the situation".

Assume a slope from A of 3° to the front and ½° to the rear; the distance A—A′=100 yards; the distance from the hostile line to our own 600 yards. A support is 100 yards behind the hostile line at Z. Both sides have "Average" marksmen.

Consider first the relative effect of the fire from A and from A′. Because of the assumption of 600 yards as the distance between the two lines, it is immaterial whether the line is at A or at A′, the range being the same in either case to the hostile line at Z.

On level ground, such as we may assume firing from A′, the support at Z′ (100 yards in rear of the target) would be hit by the part of the cone whose density is 0.64. If, however, the firing line is at A, 100 yards in rear on a 3° slope (elevation of A 15.7 feet above A′), the line of sight to Z is lowered about ½° which is the same as considering the ground at Z "rising" with respect to the line of sight the same amount or ½°. The depth of the cone is thus short-

ened $\frac{1}{2}$ and the density of Z′ (100 yards in rear) is now only 0.13. The effect against the support has decreased in the ratio 13: 64 or1:5.

With respect to the effect of the enemy's fire. The support 100 yards in rear, if on level ground would be in the cone at a density of 0.64 as we have seen. If the troops stand on the 3° slope that we assumed then the dispersion in depth is reduced to $\frac{1}{7}$ of its original depth and the density 100 yards in rear would be the same here as it would be 700 yards in rear on a plain; in other words, the support at A would not be hit at all except by scattering shots from poor marksmen.

If the firing line is at A and the support is at B. The ground from A to B falls one degree with respect to the line of sight ($\frac{1}{2}°$ slope of ground + $\frac{1}{2}°$ angle of site). The angle of fall of the trajectory at 600 yards is $\frac{1}{2}°$ hence, bullets grazing A will leave there travelling horizontally or the mean trajectory will follow the path of the 1050 yard trajectory the summit of which is at 600 yards and which has an elevation of about 16 feet. The trajectory would thus sweep the reverse slope with about the same density of the cone as at A for a distance of about 400 to 450 yards.

The final result is, therefore, that the effect on the enemy's support is five times greater when the firing line is at A′ than when it is at A; and that the effect of the enemy's fire on our supports at B is as great as on the firing line itself at A, whereas at A′ no effect at all would be felt by the support at A.

If the tactical considerations make the choice of the A position advisable, it should be clear that supports should be so placed as not to be within effective fire of the same cone as the firing line. In connection with this example it should be observed that the angle at A between the grazing shots and the reverse slope changes with the position of the hostile line at

Z, hence that supports which could not remain on the slope during the earlier and more distant firing can safely be moved close to A as soon as the hostile line has advanced to such a point that the angle referred to becomes great enough to form a dead space in rear of A. Hence the general rule for advancing supports up to the line on a reverse slope as the hostile line approaches.

THE BAYONET

Probably no other part of the soldier's armament has been the subject of so much discussion and thought as the bayonet. After every war a corps of pamphleteers spring up who, often from incomplete data, draw conclusions based on the experiences of the war and who point the way to the changes which the improvement in material has effected as demonstrated on the field of battle. These ideas at once find a host of supporters and an equal number of opponents so that it is extremely difficult for an outsider to choose between the two points of view presented or to arrive at a just estimate of the truth of the proposition put forth. After the Boer war we were shown that the bayonet was obsolete and useless, After the Russo-Japanese war we were shown with equal fervor and conviction that in the future the bayonet will frequently be used.* It seems probable, however, that while the number of actual bayonet encounters will be very small, yet that the MORAL force of possessing as good a bayonet as the opponent will always repay an army for carrying the very best and most effective weapon that can be devised for use on those casual occasions when shock action becomes necessary, for it must be remembered that the

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*Russian / ~~14.5~~ per cent	Wounded by bayonet	1600.
	Total wounded	113,755.
*Japanese / 0.69 per cent	Killed and wounded by bayonet	526.
	Total wounded - - -	76.585.

defender's line seldom breaks simultaneously, but that first individuals, then groups of men leave the line and that it is the *threat* of the bayonet assault which makes the rest decide to follow.

The use to which the bayonet will be put in battle has, indeed, changed with the altered conditions of modern war and in a very broad way it may be stated that the change is shown by the reversed attitude of the world on the subject of the two great means of overcoming an enemy on the field of battle —*fire action* and *shock action*. Not many years ago the use of fire action was entirely secondary to the application of physical force with the bayonet; today it is quite as generally accepted that the shock is incidental, that—as more than one epigrammist has stated "Fire is everything, the rest of small account".

The presence of the best bayonet then may be regarded as a very real and powerful moral adjunct to the side which possesses it. Occasions for its use in threatening a stubborn enemy may occur at any time, as, for example, in the fight at Metz where "The mere sight of the attack that was under way from Point-du-Jour sufficed to put to flight the infantry, about 400 strong and under good cover, holding the gravel pits." (Hönig). The occasions where bayonets will be crossed however, will be few, and one must beware lest its posession (and the peace training of the "normal attack" which always terminates with a loud hurrah and a bayonet charge) blinds one to its real importance. Too often is a bayonet charge the result of uncalled-for bravery, a way out of a difficult situation of one's own making, or else the cry of despair, the forlorn hope of an infantry which knows itself to be opposed by an enemy superior in every way—in its fire and in its entrenched position.

SUMMARY

The latest "Regulations Respecting Infantry Fire in the German Army" summarize the subject of Fire Direction and Discipline in the following words;

"Fire Direction comprehends:

The opening and cessation of fire;
Choice and indication of the mark;
Estimate of the distance;
Estimate of the sight, and under certain circumstances, of the point to the aimed at, while taking account of the influence of atmospheric conditions;
Determination of the kind of fire and its distribution;
Observation of the objective;
Action of the commander respecting the manner in which the men behave in battle;
Fire Discipline.

Any arbitary limitation of the initiative of each grade would be contrary to the spirit of modern infantry action.

Preparation in time of peace guarantees in battle cöoperation of effort on the part of each one in the line of his duties.

Commanders of high rank must not permit themselves to be withdrawn from their higher functions by the direction of details.

In order that the grades may be ready, of their own initiation, to step outside their prerogatives, when the exigencies of action so require, the trend of their training should be to develop a sense of responsibility and a resolute spirit.

The expediency of opening fire must be determined .by the commander. It depends primarily upon the tactical situation.

He should not commence the fire until it can be rendered effective. Premature opening of fire denotes disquiteude and lack of assurance.

A heavy expenditure of ammunition without corresponding results has for its corollary an expenditure of forces that is profitless and therefore detrimental. Inadequate effects increase the enemy's assurance.

The amount of ammunition accounted necessary for accomplishing the purpose of the action should be expended unhesitatingly.

An immediate cessation of fire should always be possible. When the adversary disappears the firing should cease of itself.

The commander should endeavor to keep control of the firing line as long as possible.

It is quite difficult to communicate orders to a line of skirmishers engaged in a sharp musketry encounter. Therefore the utmost pains must be exercised in the training of the men.

The selection of objectives depends upon the tactical situation. Considerations in reference to the dimensions of the targets are of secondary importance.

Changes of objectives cause confusion and waste of ammunition and should not occur unless the combat situation absolutely demands it or unless it has become considerably modified.

The designation of the objective should be as concise as possible; it should remove all doubt and enable the marksman readily to discover the target. If the latter is not discernable without the aid of field glasses, some object of the terrain must be designated as the point at which to aim. It may even be of advantage to circulate field glasses along the line of riflemen.

Hostile fractions are described as they are observed by the riflemen (artillery piece farthest from the right, etc.).

Distances are estimated most accurately by the

use of telemeters. They may also be measured by an enlarged map, or learned from the fractions of artillery or infantry in the neighborhood, or even estimated by sight. For the latter method the platoon chief uses the most skillful noncommissioned officers. Moreover, he retains near himself as estimators of distances two or three trained men who communicate to him their estimates. These men are of further assistance to him in observing not only the object of fire, but also other parts of the battlefield, and in maintaining communication with the next higher commanders.

In exceptional cases and when the troops are not under an effective fire, the exact elevation may be found by opening fire in volleys by section or platoon with a single sight, or by executing rapid fires. To secure results by this method the objective should be motionless, the terrain in front of the target visible, the points of fall of the bullets observable and the available time sufficient.

The elevation at the beginning should be low enough that the points of fall of the projectiles may be in front of the target.

Estimated distances form the basis for determining the elevation to be selected. Also there should be always taken into account atmospheric influences, the longitudinal dispersion and for short ranges, the extent of the dangerous zone.

Up to one thousand meters (1100 yards) only a single sight should ever be employed.

Beyond 1000 meters when the distance is unknown, two sights differing by 100 meters (110 yards) should generally be employed. The chief may, however, deviate from this rule if through reliable estimates or through observation of the points of fall, he has a sure basis for determining the sight to be selected. In this case he may, with only a single sight, ex-

ecute fire even beyond 1000 meters; or he may take two sights differing only by 50 meters.

As a general rule the foot of the target should be aimed at. When observation of shots is possible and the objective presents broad intervals, it may be advantageous, at short distances and with well trained troops, to leave the selection of the point of aim to the marksman.

Rapidity of fire should be regulated by the tactical situation, the purpose of the action, the nature of the objective and the supply of ammunition.

Volley fire should be employed only when troops are not subjected to an effective fire.

It is especially important that the fire should be uniformly distributed over the whole breadth of the front to be swept. It is therefore necessary to indicate with precision to the inferior units the limits within which their fire must be distributed. In order that no portion of the object aimed at may escape the fire, it is recommended that the fractions slightly enroach upon each other.

Generally each fraction and each marksman should endeavor to hit the part of the objective opposite to him; and yet cross-fires also have their place. But under no circumstances should the indistinctness of the objective assigned to them induce the chiefs or marksmen to definitely include in their fire any other point more plainly visible. This does not exclude taking advantage of especially favorable opportunities such as rushes on the part of the enemy, etc.

In estimating effectiveness, the distribution of fire should not be disregarded.

The points of fall of the projectiles must be constantly observed through field glasses. From their disposition and the attitude of the enemy it can be reckoned whether the sight and point of aim have

been well selected or whether a change is necessary.

If, on the firing line direct observation becomes impossible, it is recommended to establish, if possible, lateral posts for transmitting their observations by signals, voice or intermediate posts.

In all service practice, the orders of all the chiefs should be given from the positions which they would occupy in action.

Fire discipline includes a rigorous carrying-out of all the orders issued respecting the execution of firings and a scrupulous observance of the directions respecting the handling of weapons and behavior in action.

It requires a judicious utilization of the terrain for increasing accuracy in firing and safety to the marksman; a correct setting of the sight and carefullness in discharging the weapon; rapidity of fire to be obtained only by quickness of loading and aiming; constant observation of the chiefs and of the enemy; spontaneous acceleration of fire as the object aimed at becomes more vulnerable and immediate cessation of fire when it disappears; finally, economy of ammunition.

When, during the action, fire direction can be no longer perfectly realized, or when it entirely ceases, each man should remain cool and be able to select for himself his objective and elevation; while the bolder and more intelligent should endeavor to draw their comrades after them by their attitude and by example."